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Yagyu et al.

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(54) **VIBRATING FEEDER, CARRYING DEVICE AND INSPECTION DEVICE**

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B65G 47/14 (2006.01)

(52) **U.S. Cl.** **198/757**; 198/759; 198/771

(58) **Field of Classification Search** 198/757, 198/759, 771

See application file for complete search history.

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Primary Examiner — Mark A Deuble

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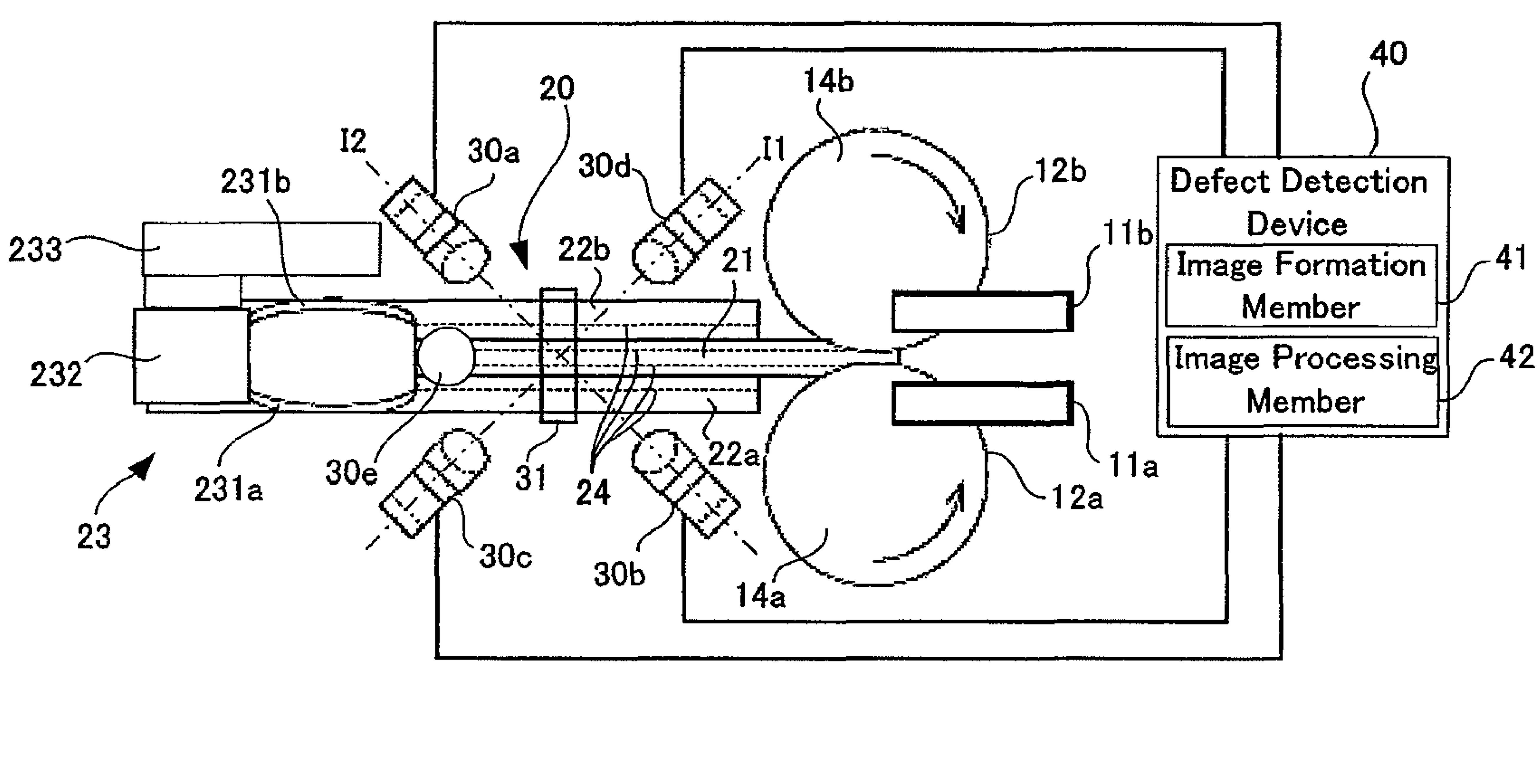
(57) **ABSTRACT**

A vibrating feeder provided with a feeder ball **14***a* having a circular bottom wall and a conveyance path formed along the periphery of the bottom wall **141***a*; a feeder body **16***a* supporting the feeder ball **14***a* so as to apply torsional vibration and conveying substance supplied on the bottom wall **141***a* along the conveyance path; and a main body supporting member for supporting the feeder body; the conveyance path comprising an ascending rail and descending rail disposed in the downstream of the ascending rail in the conveyance direction; the main body **18***a* supporting member supporting the feeder body **16***a* on a horizontal floor so that a torsion axis C, which becomes the center of the torsional vibration, is inclined relative to the vertical direction; the ascending rail and descending rail conveying the conveyed objects upwardly or downwardly relative to the horizontal direction while the feeder body being supported by the horizontal floor via the main body supporting member.

10 Claims, 15 Drawing Sheets



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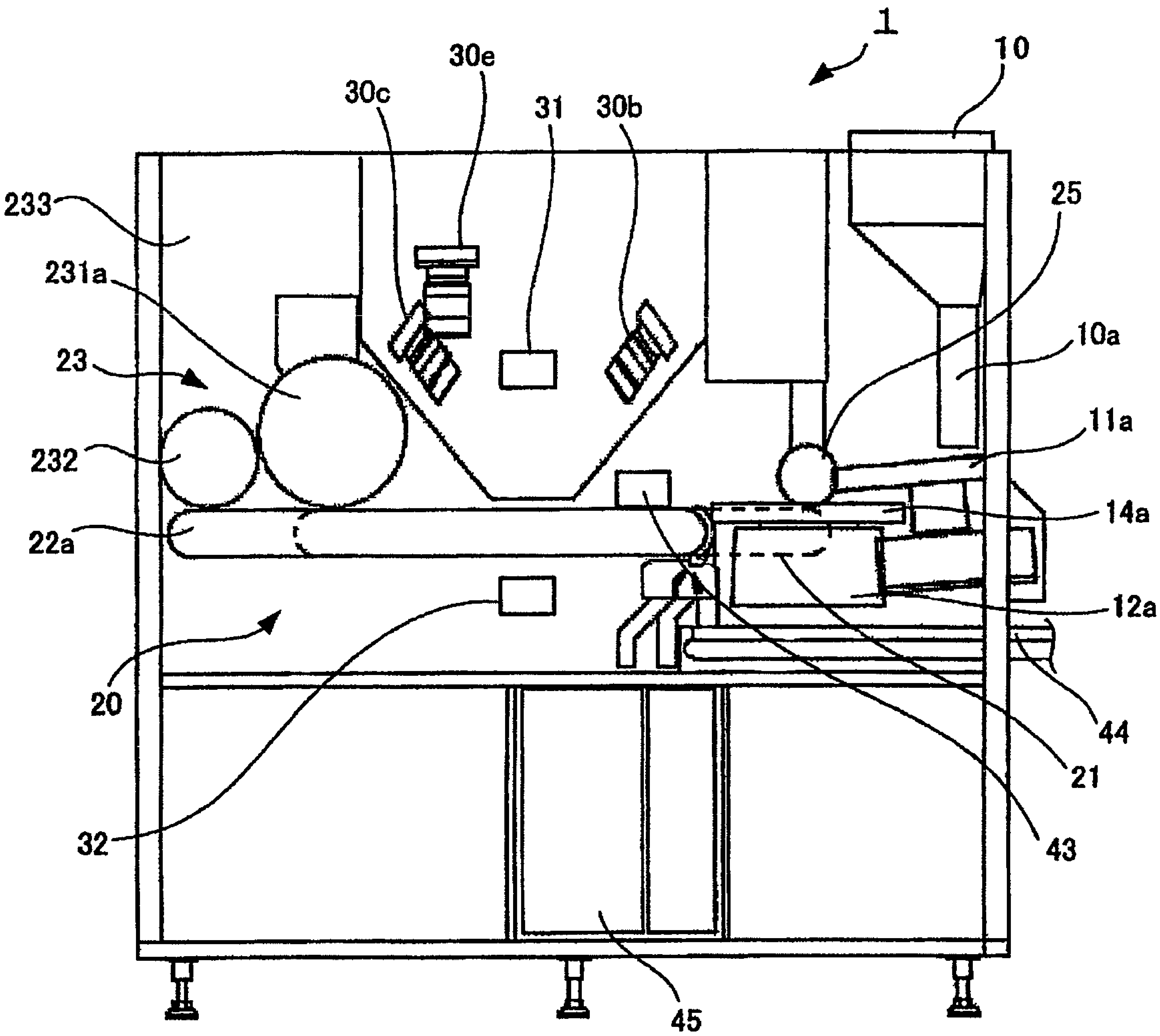
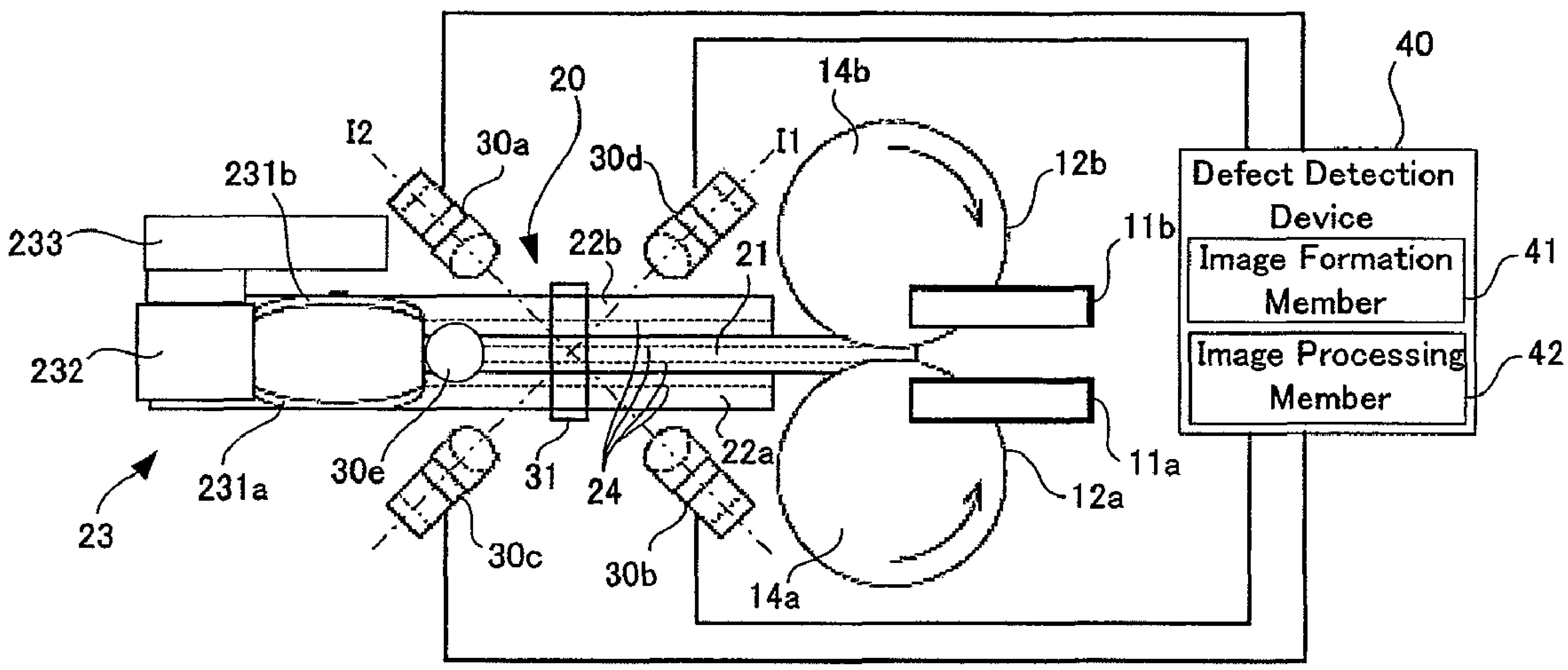
[Fig. 1]

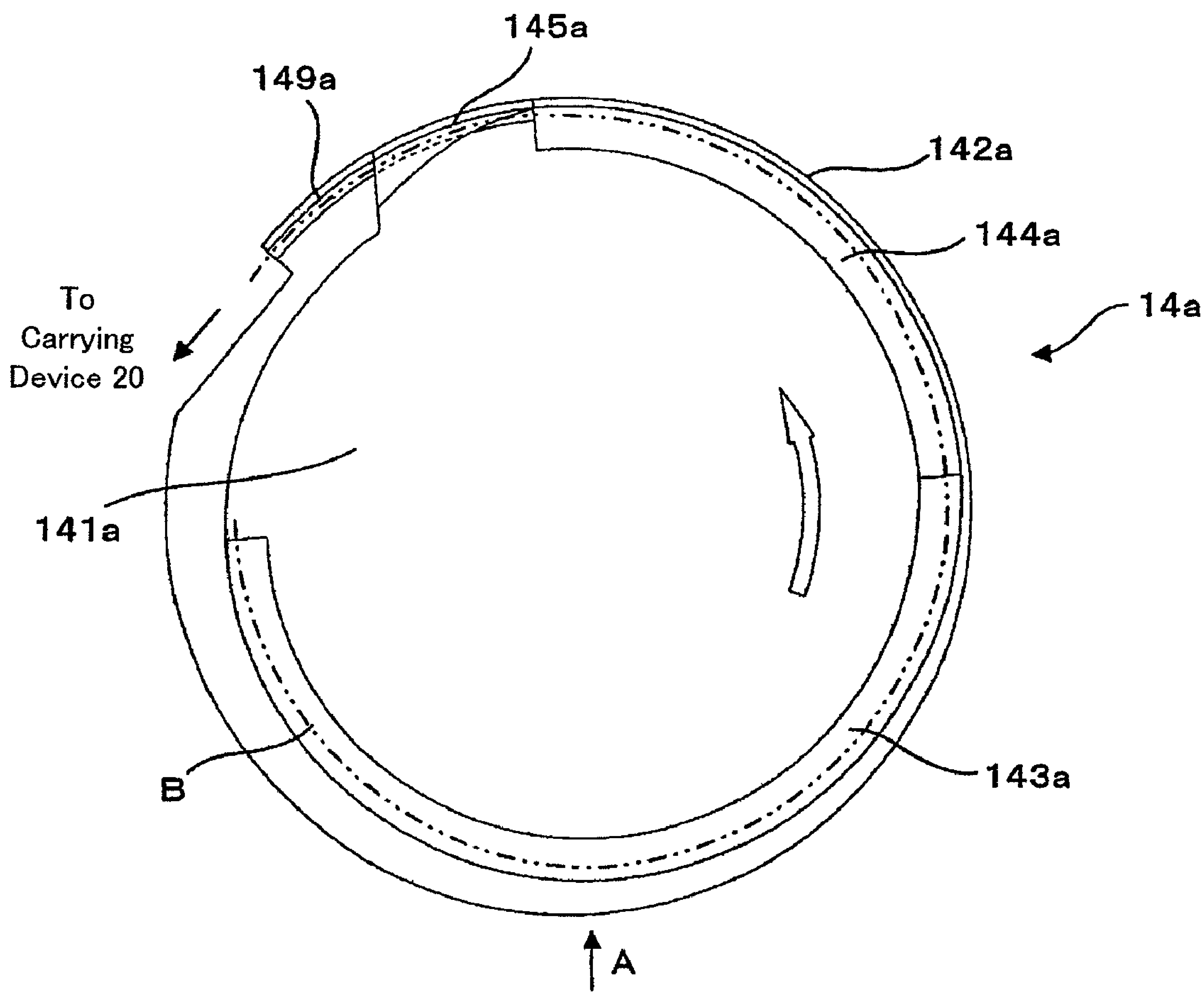

1
10
30e
30c
31
30b
233
25
231a
10a
23
11a
232
14a
22a
12a
20
44
21
32
43
45

[Fig. 2]

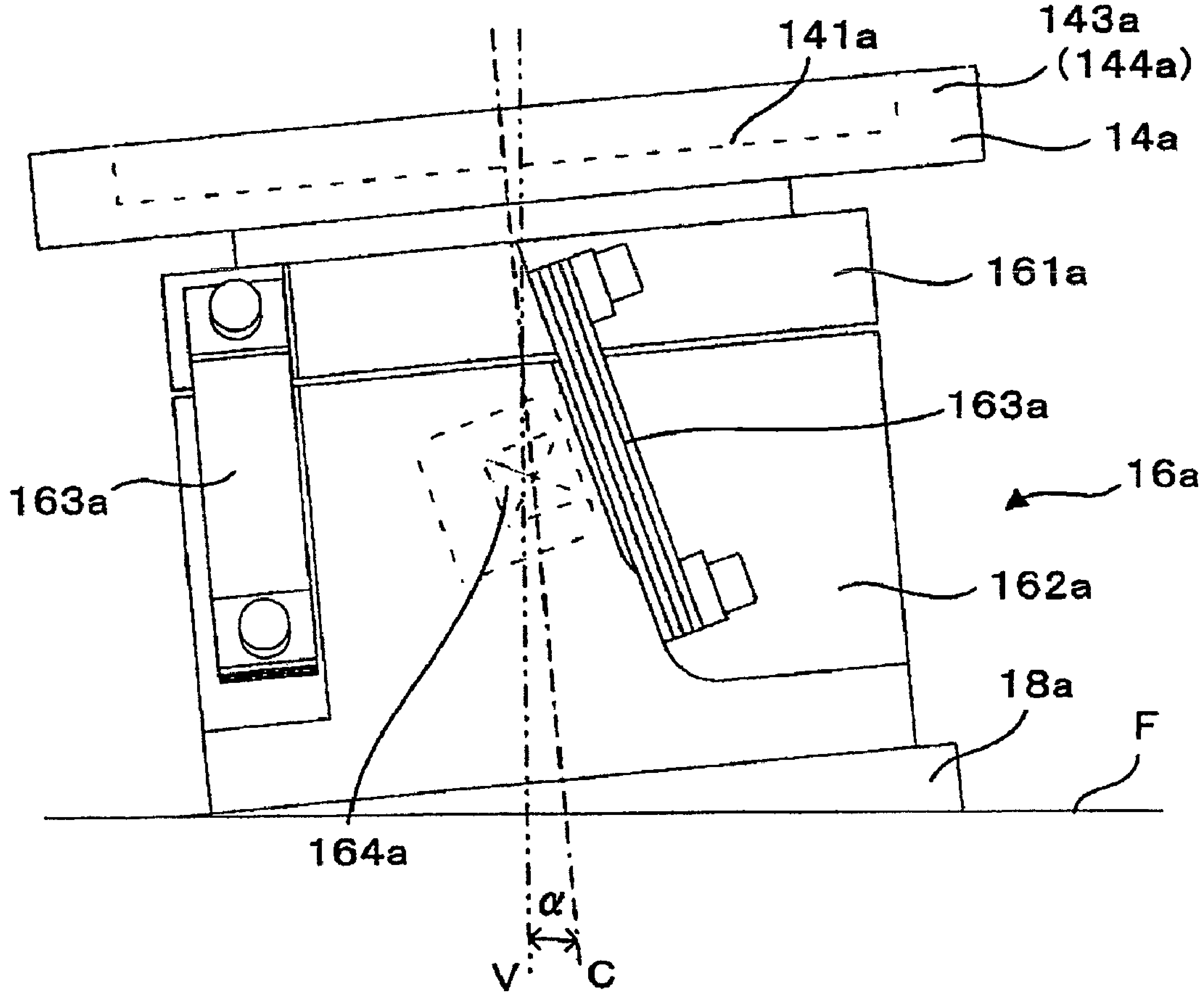


20
40
14b
I2
30a
30d
I1
12b
231b
Defect Detection Device
233
22b
11b
Image Formation Member
41
21
232
Image Processing Member
42
11a
22a
30e
231a
31
24
12a
23
30c
30b
14a

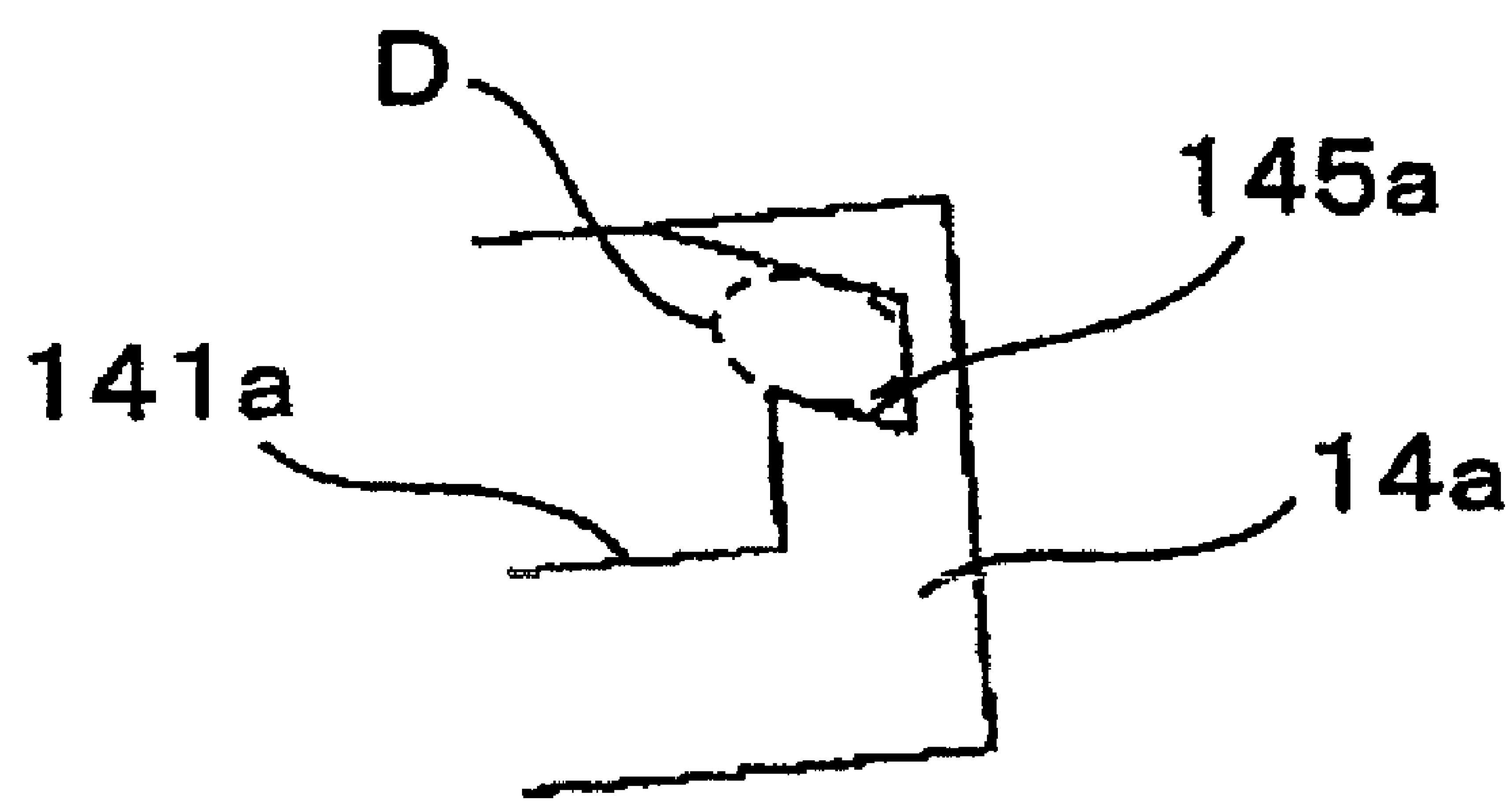
[Fig. 3]



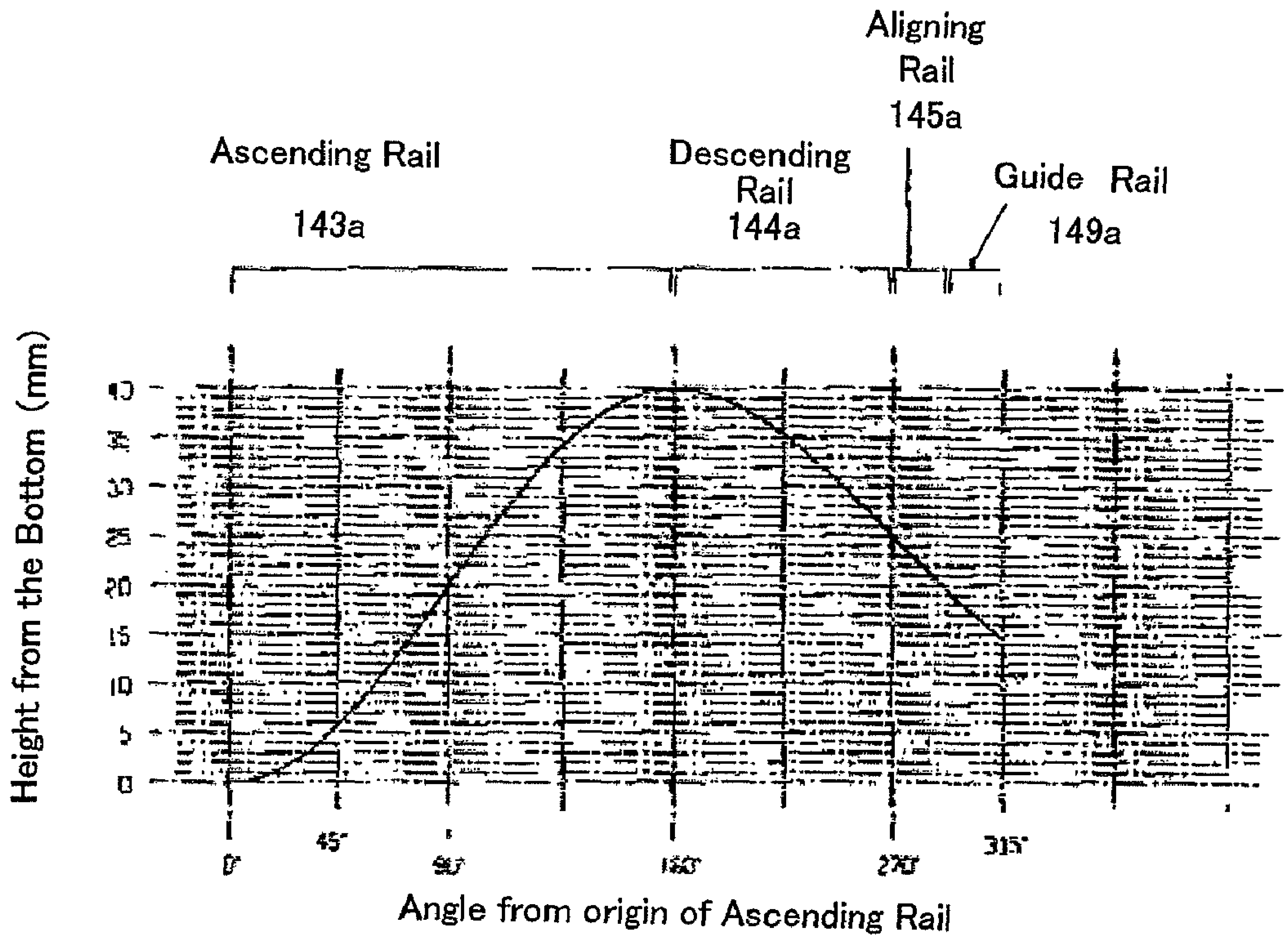
[Fig. 4]



[Fig. 5]

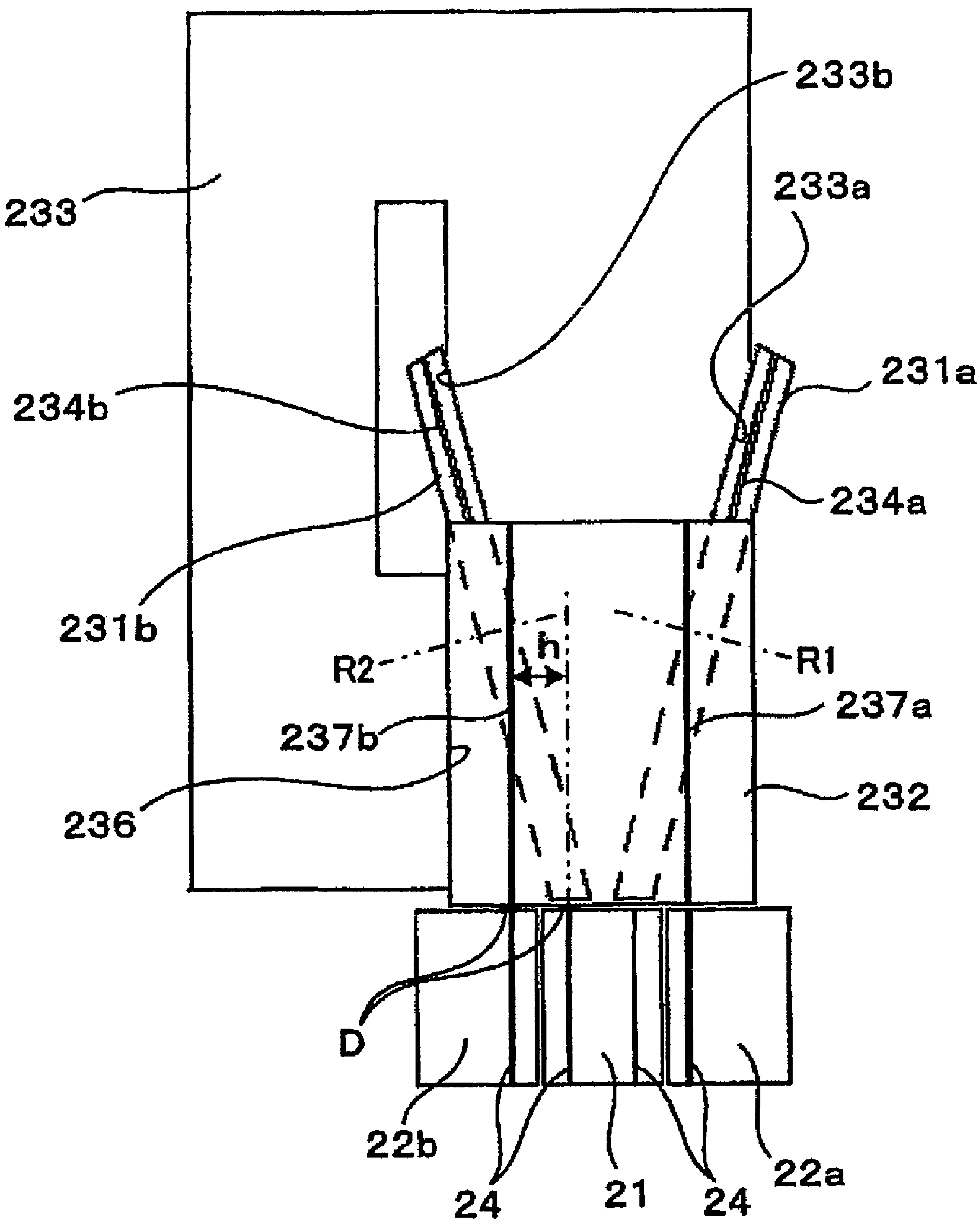


[Fig. 6]

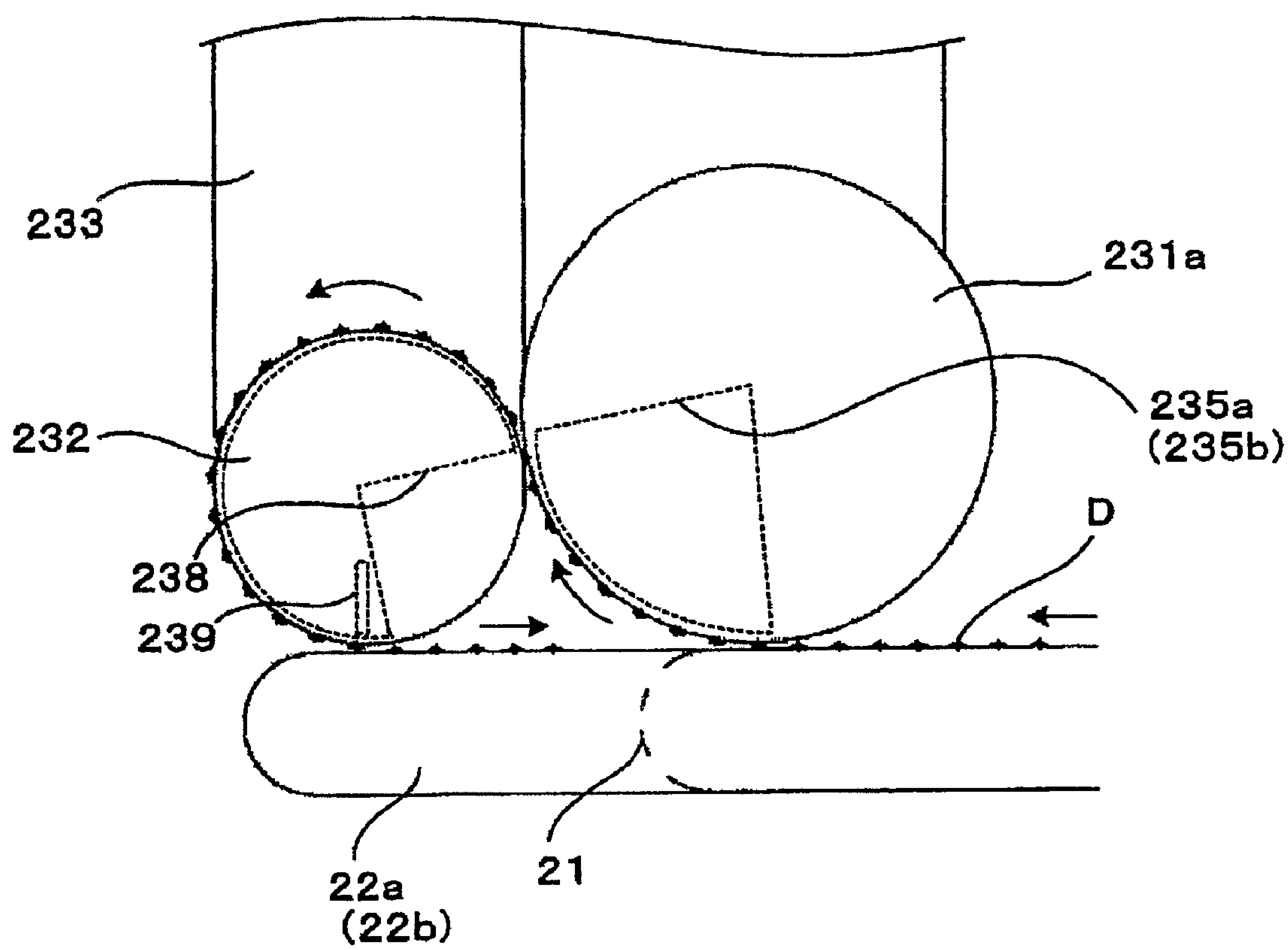


Aligning Rail
145a
Ascending Rail
143a
Descending Rail
144a
Guide Rail
149a
Height from the Bottom (mm)
40
35
30
25
20
15
10
5
0
0°
45°
90°
180°
270°
315°
Angle from origin of Ascending Rail

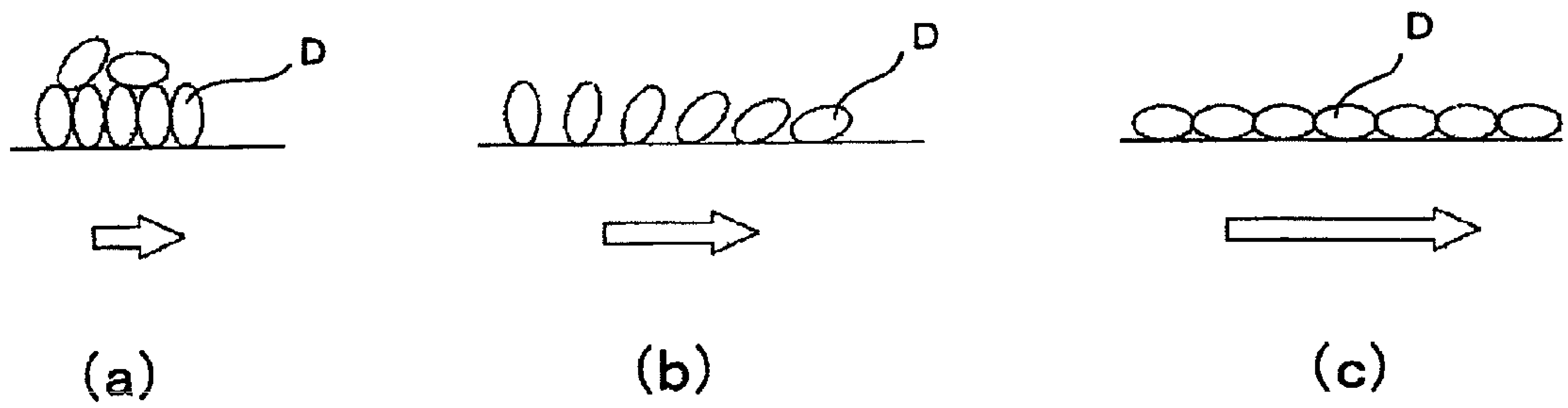
[Fig. 7]


233b
233
233a
231a
234b
234a
231b
R2
h
R1
237a
237b
232
236
D
22b
24
21
24
22a

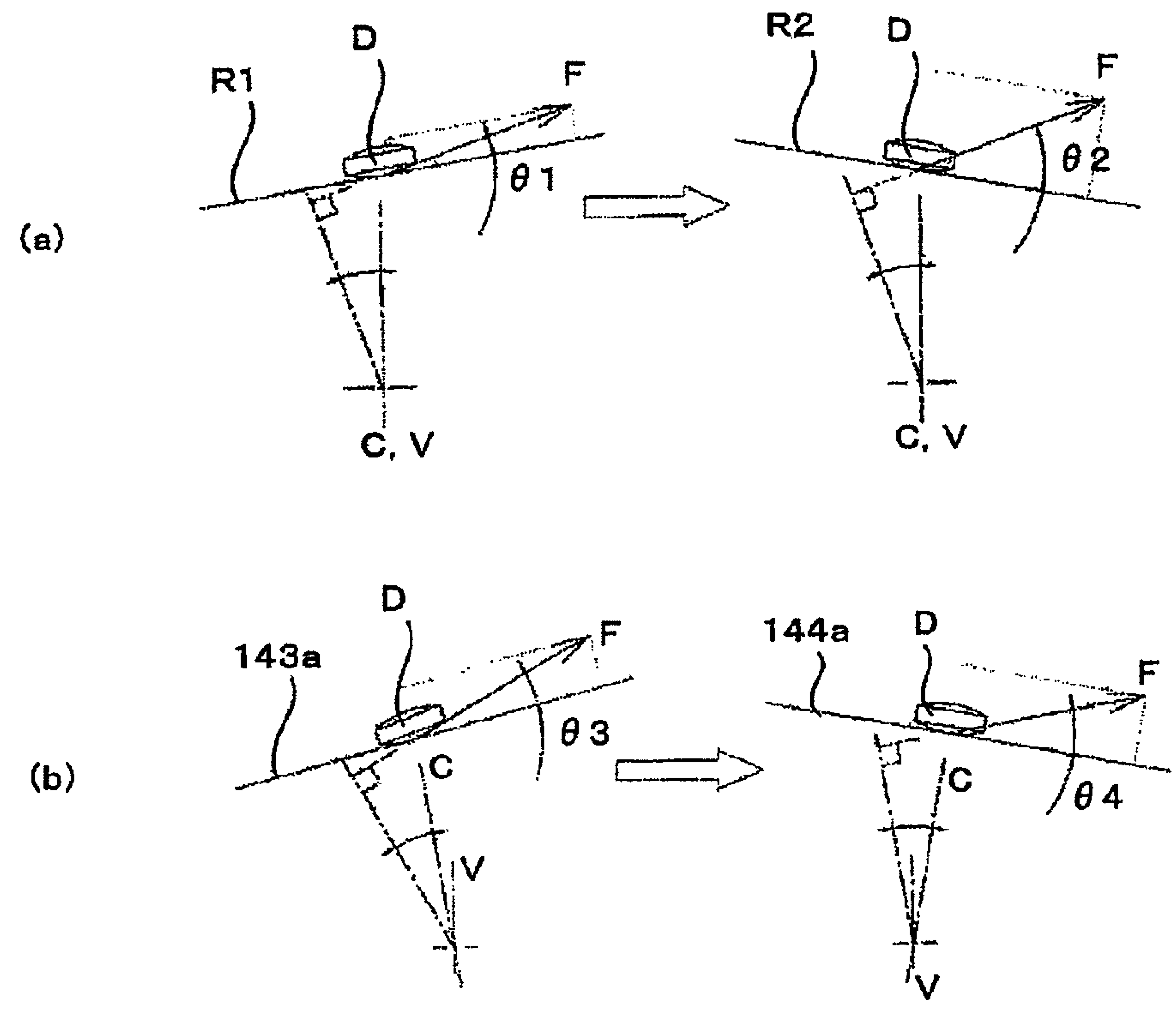
[Fig. 8]



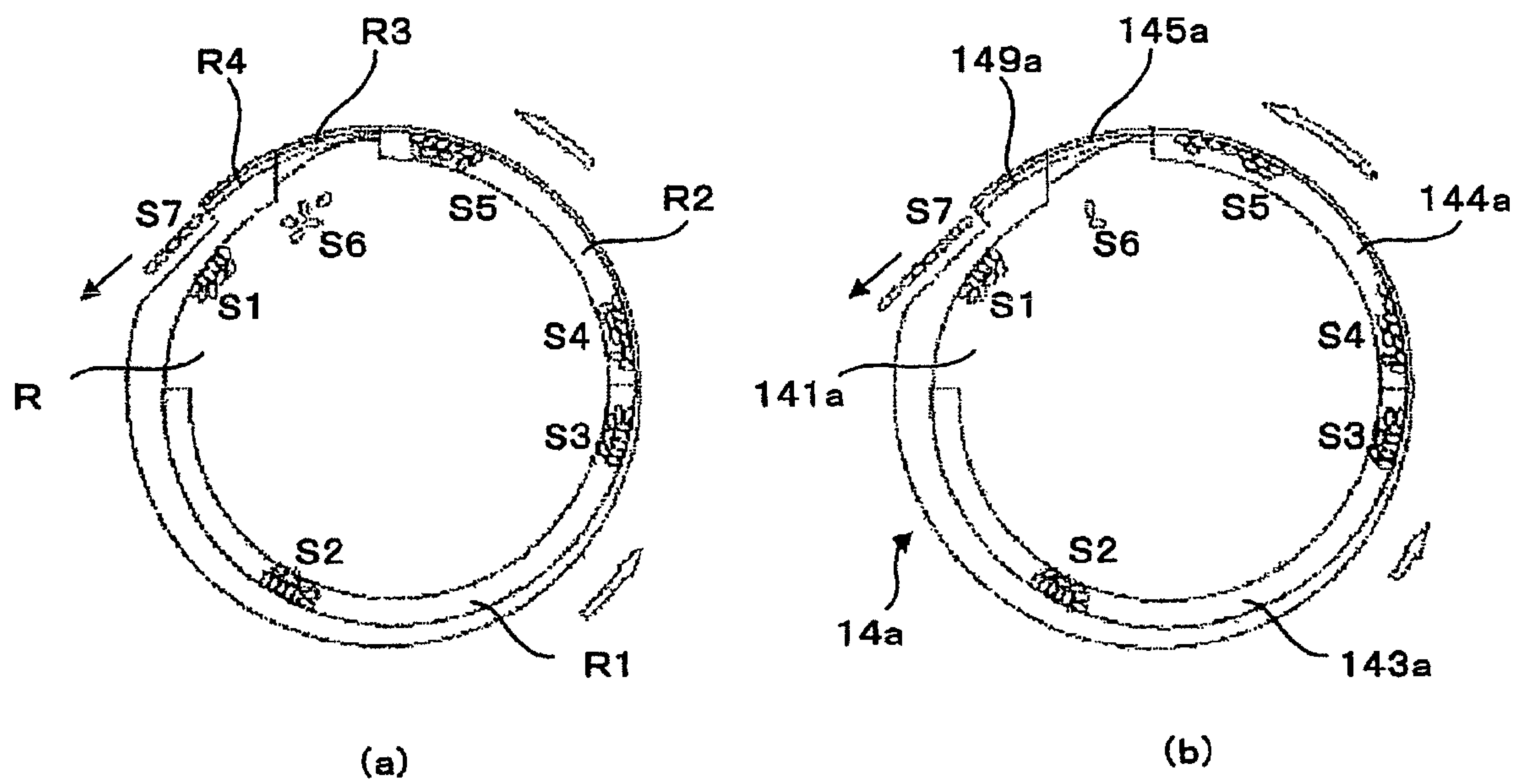
[Fig. 9]



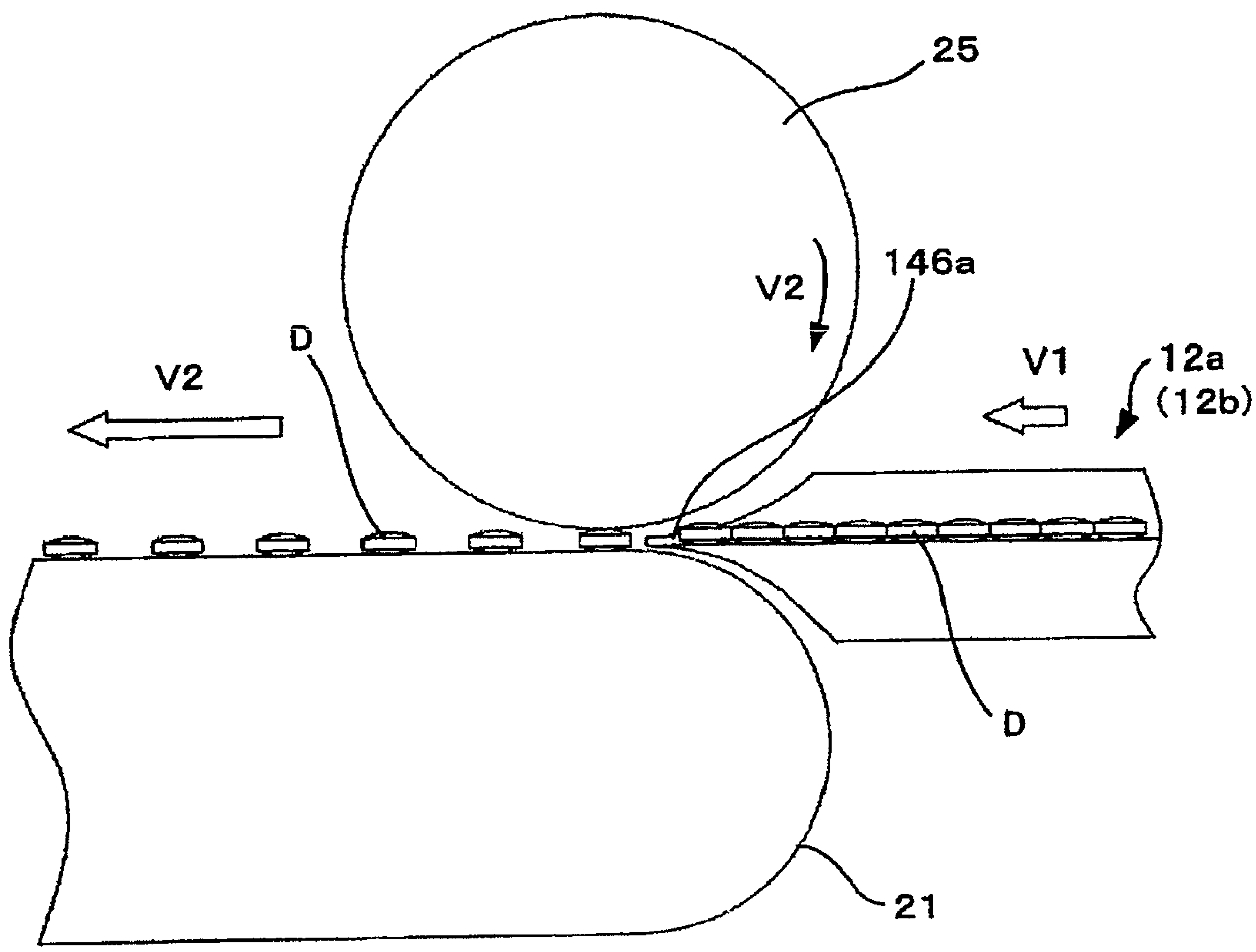
[Fig. 10]



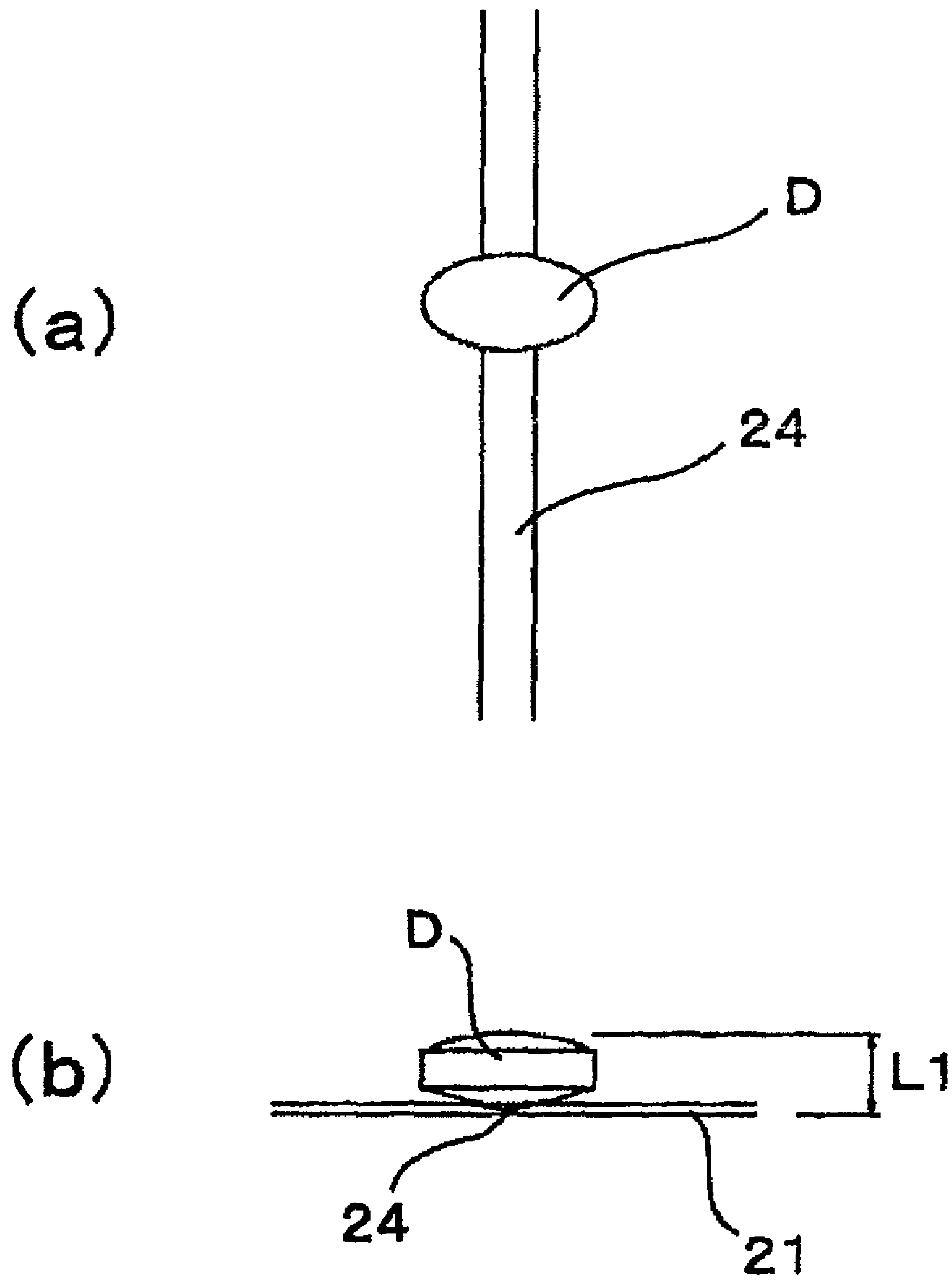
[Fig. 11]


R3
R4
S7
S6
S5
R2
S1
S4
R
S3
S2
R1
(a)
145a
149a
S7
S6
S5
144a
S1
S4
141a
S3
S2
14a
143a
(b)

[Fig. 12]

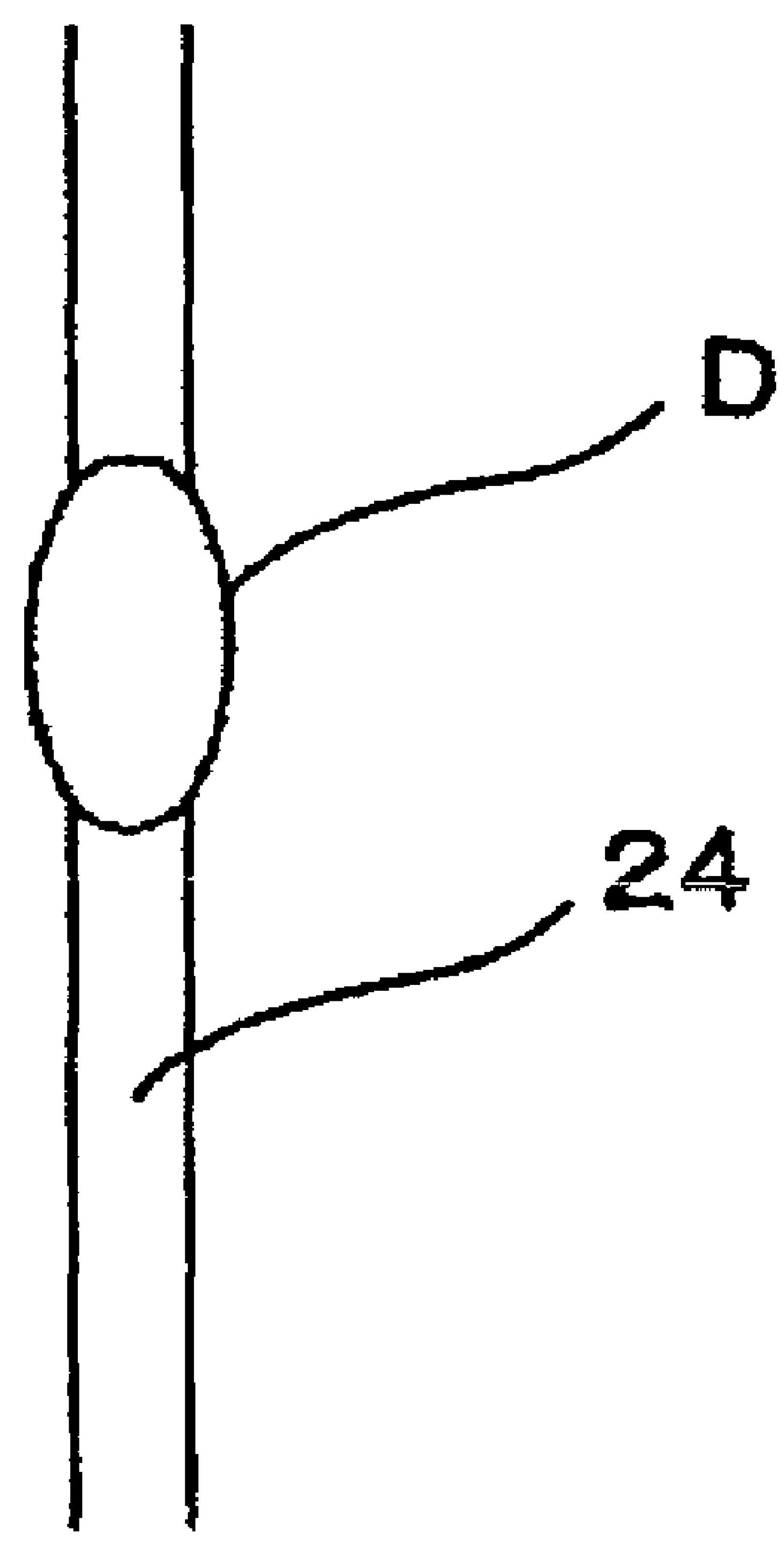


[Fig. 13]

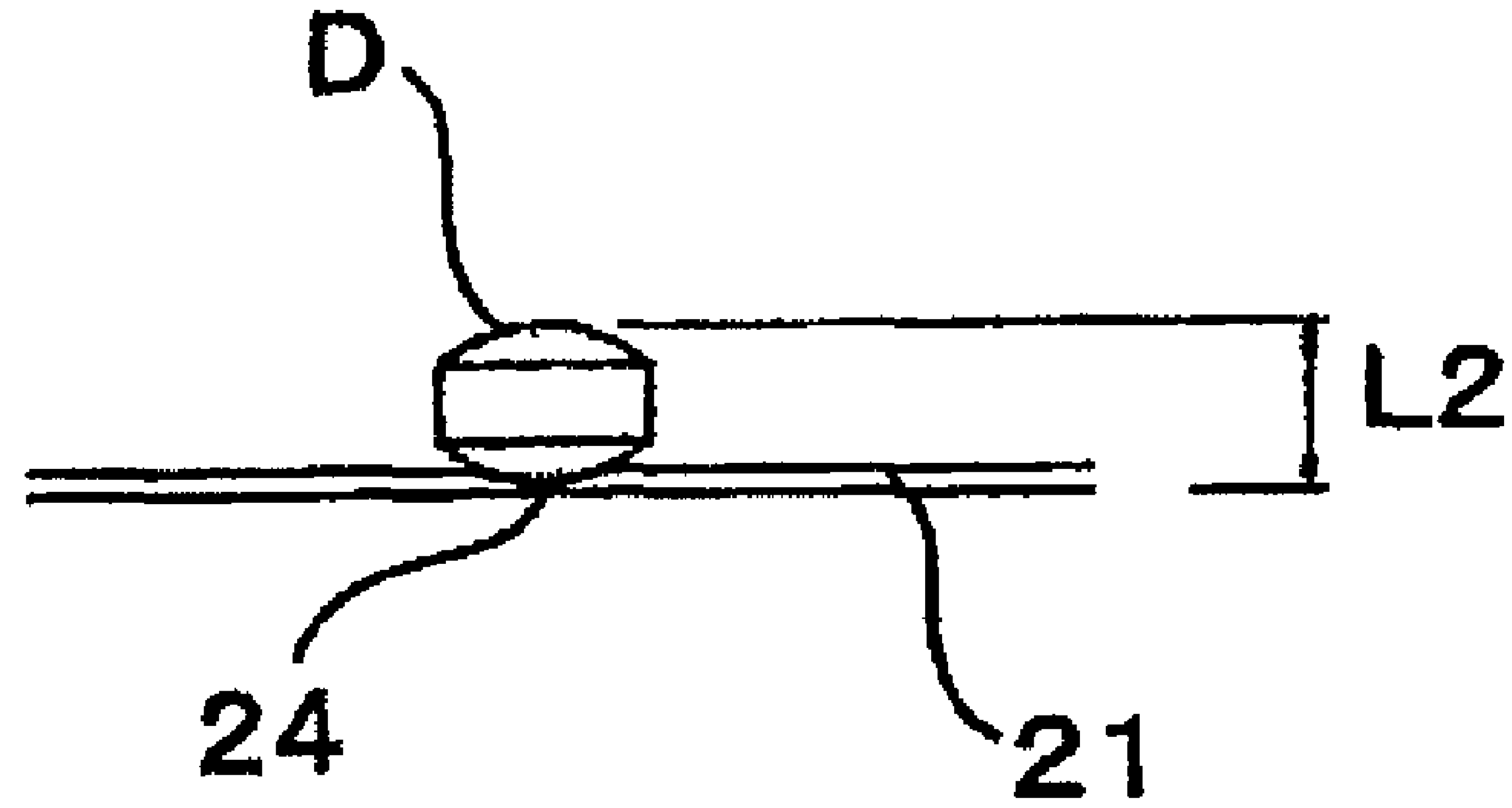


[Fig. 14]

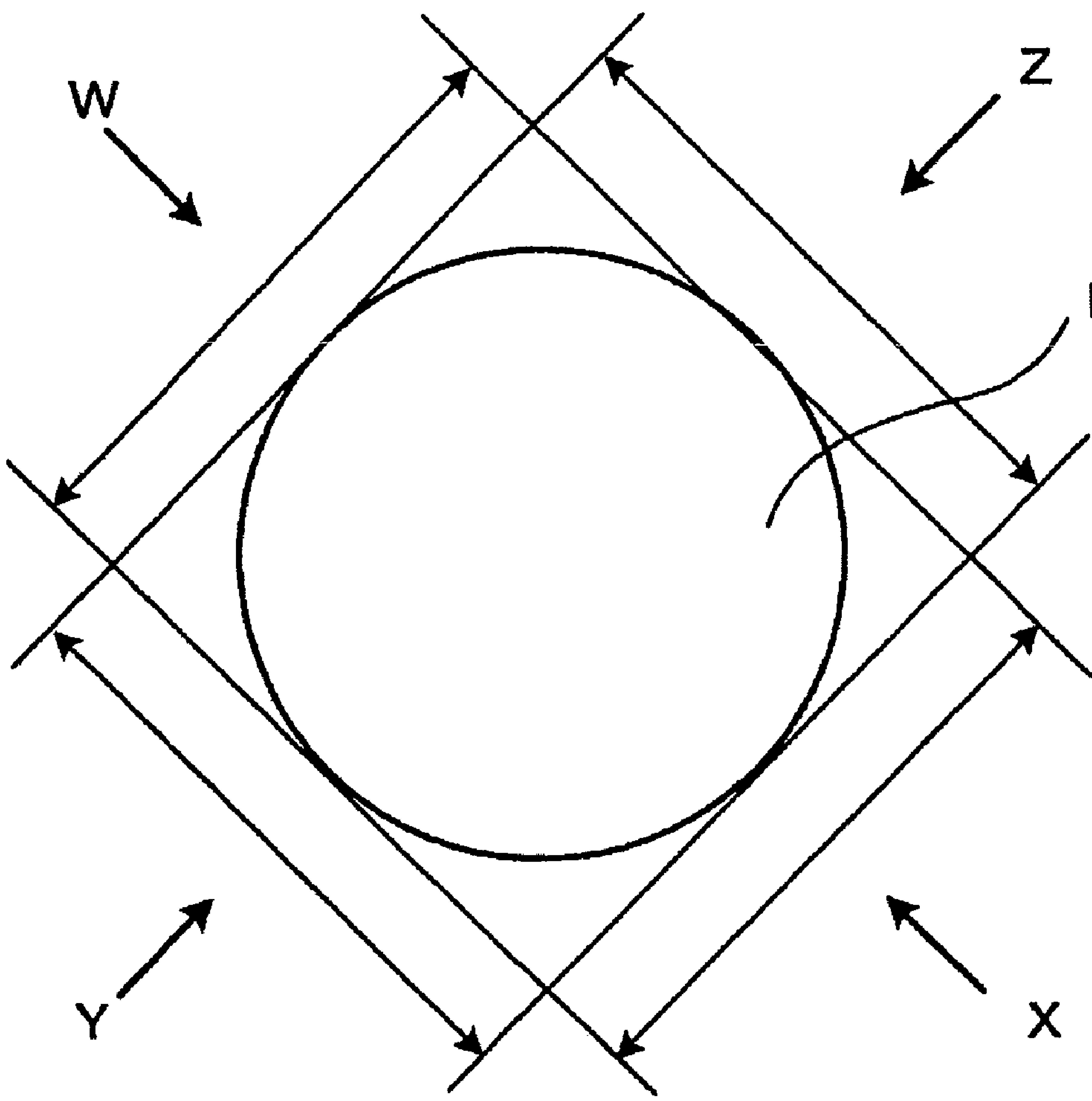
(a)



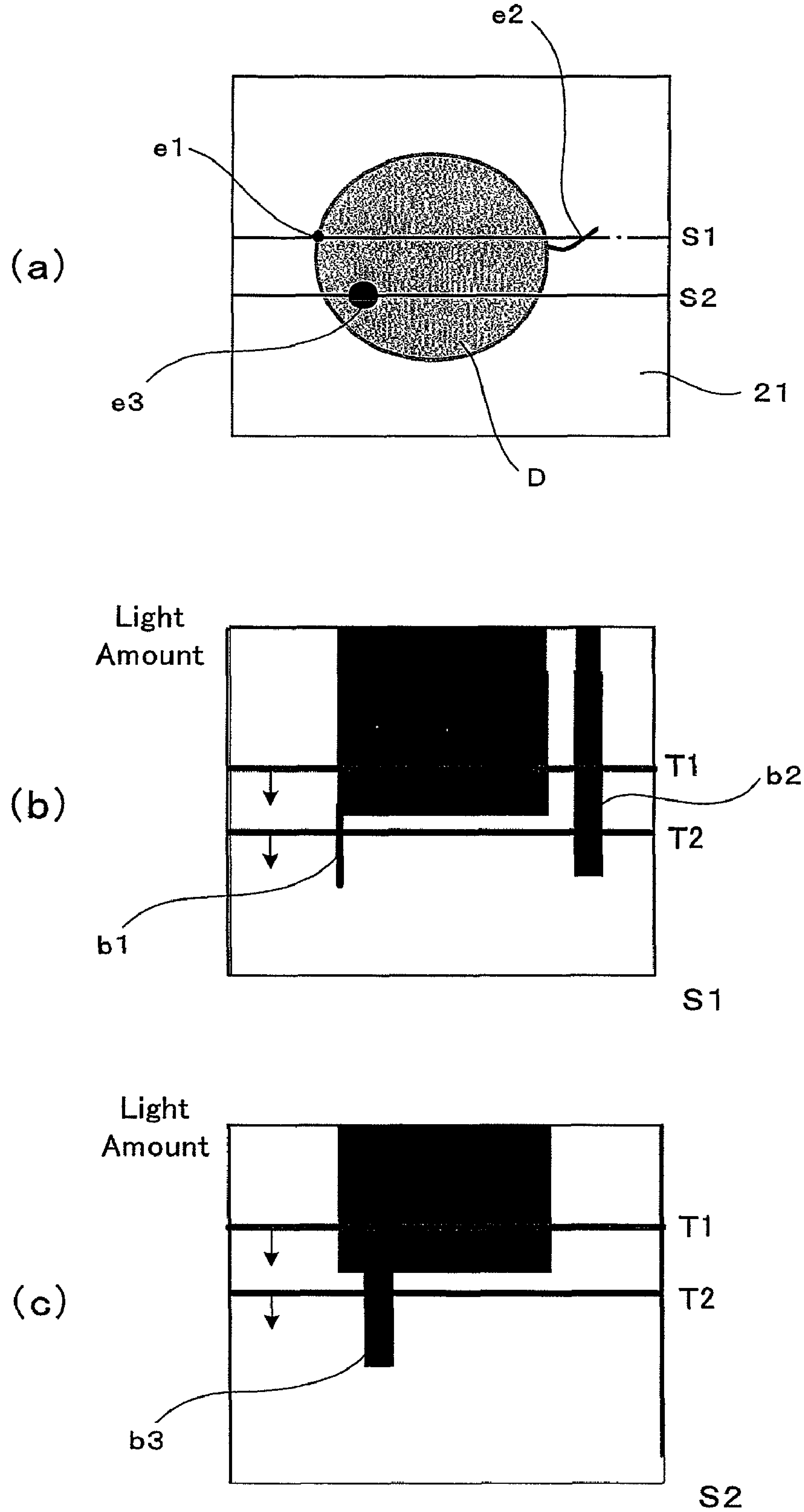
(b)



[Fig. 15]



[Fig. 16]


(a)
e1
e2
e3
S1
S2
21
D
(b)
Light Amount
T1
T2
b1
b2
S1
(c)
Light Amount
T1
T2
b3
S2

VIBRATING FEEDER, CARRYING DEVICE AND INSPECTION DEVICE

TECHNICAL FIELD

The present invention relates to a vibrating feeder for carrying tablets, capsules and like objects by vibration. Furthermore, the present invention relates to a carrying device and inspection device provided with such vibrating feeder.

BACKGROUND ART

There are several conventionally known devices for use in inspecting the appearance of tablets or like conveyed objects while transporting them, so that adhesion of foreign matter, contamination, cracking of the conveyed objects and like defects can be detected. For example, Patent Document 1 discloses an appearance inspection device by which tested objects placed in a hopper are supplied to a vibrating feeder, and then the objects are conveyed with vibration in an aligned state by the vibrating feeder. The tested objects are supplied from the vibrating feeder to an inspection drum where the appearance inspection is conducted.

Tested objects are continuously supplied from the hopper to the feeder ball, which forms the conveyance plane of the vibrating feeder. Therefore, the tested objects are conveyed in a condition such that they are piled onto the feeder ball, and this may hinder the constant feeding of the tested objects. To prevent this, Patent Document 2 discloses a structure wherein the excessive supply of the tested objects is prevented by providing a leveling plate in a conveyance path so that the height of the pile of tested objects is leveled.

Patent Document 1: Japanese Unexamined Patent Publication No. 2001-33392

Patent Document 2: Japanese Unexamined Patent Publication No. 2007-76819

DISCLOSURE OF THE INVENTION

Problem to be Solved by the Invention

The vibrating feeder disclosed in Patent Document 2 forcibly controls the conveyance amount of the objects by providing a leveling plate so as to narrow the space through which the objects pass. Therefore, the tested objects may easily crack or break when they pass through the leveling plate due to the impact or external force applied thereto. In recent years, in order to enhance inspection efficiency, vibrating feeders having a very high conveyance speed are demanded, and therefore the above described problem has become more critical than ever.

An object of the present invention is to provide a vibrating feeder that can align and convey objects at a high conveyance speed without damaging them. Another object of the present invention is to provide a carrying device and inspection device provided with such a vibrating feeder.

Means for Solving the Problem

An object of the present invention can be achieved by a vibrating feeder that is provided with a feeder ball having a circular bottom wall and a conveyance path formed along the periphery of the bottom wall; a feeder body for supporting the feeder ball so as to apply torsional vibration and for conveying objects supplied to the bottom wall along the conveyance path; and a main body supporting member for supporting the feeder body.

In the vibrating feeder, the conveyance path has an ascending rail and a descending rail that is disposed downstream from the ascending rail in the conveyance direction.

The main body supporting member supports the feeder body on a horizontal floor so that a torsion axis, which is the center of the torsional vibration, is inclined relative to the vertical direction.

The ascending rail and the descending rail respectively convey objects upwardly or downwardly relative to the horizontal direction with the feeder body being supported by the horizontal floor via the main body supporting member.

An object of the present invention can also be achieved by a carrying device provided with the above-described vibrating feeder for use in conveying objects, having a conveying means for receiving the objects delivered by the vibrating feeder and conveying the objects in a single direction; and press rollers for pressing the objects against the conveyance plane of the conveying means disposed in the location where the objects are transferred from the vibrating feeder to the conveying means.

An object of the present invention can also be achieved by an appearance inspection device provided with the above-described vibrating feeder for inspecting the appearance of the objects, having a forward conveying means for receiving the objects delivered by the vibrating feeder and conveying the objects in a single direction; a returning means for conveying the objects in the direction opposite to that of the forward conveying means, the returning means being disposed in parallel to the forward conveying means; and a back/front reversal means for turning over the front and back surfaces of the objects delivered by the forward conveying means and supplying the objects to the returning means; a plurality of image-pickup means for capturing images of each object from upper oblique directions along the same scanning line while the object is being conveyed by the forward conveying means and returning means; and a defect detection means for detecting the presence of defects based on image data captured by the image-pickup means.

Effect of the Invention

The vibrating feeder, carrying device and inspection device of the present invention make it possible to convey objects in an aligned condition at a high speed without damaging the objects.

BEST MODE FOR CARRYING OUT THE INVENTION

Hereunder, an embodiment of the present invention is explained in detail with reference to the attached drawings. FIG. **1** shows a side elevation view of the appearance inspection device according to one embodiment of the present invention, and FIG. **2** is a plan view of the main components of the appearance inspection device of FIG. **1**.

As shown in FIGS. **1** and **2**, the appearance inspection device **1** is provided with a hopper **10** through which tablets and like conveyance objects are supplied; vibrating feeders **12***a* and **12***b* for conveying the objects supplied from the hopper **10** while aligning them; a carrying device **20** for conveying the objects sequentially supplied from the vibrating feeders **12***a* and **12***b*; five image-pickup devices **30***a*, **30***b*, **30***c*, **30***d* and **30***e* for capturing images of the objects being conveyed by the carrying device **20**; and a defect detection device **40** for detecting the existence of defects in the objects based on image data of each of the image-pickup devices **30***a* to **30***e*.

The vibrating feeders **12***a* and **12***b* are adjacently provided on the right and left of the hopper **10**. The conveyed objects are supplied from the two outlets **10***a* and **10***b* formed in the lower portion of the hopper **10** via chutes **11***a* and **11***b* respectively. The objects supplied to the vibrating feeders **12***a* and **12***b* are conveyed by vibration in the direction shown by the arrow in FIG. **2**.

FIG. **3** shows an enlarged plan view of a feeder ball **14***a* that serves as a conveyance plane of the vibrating feeder **12***a*. The feeder ball **14***a* has a circular bottom wall **141***a* and an annular guide wall **142***a* provided along the rim of the bottom wall **141***a*. At the periphery of the bottom wall **141***a*, an ascending rail **143***a*, descending rail **144***a*, and aligning rails **145***a* are disposed in such a manner that they sequentially connect in this order along the guide wall **142***a*.

FIG. **4** is a side elevation view of one of the vibrating feeders **12***a*, which is seen from the direction of arrow A in FIG. **3**. The vibrating feeder **12***a* is provided with the above-described feeder ball **14***a*, a feeder body **16***a* for supporting the feeder ball **14***a*, and a main body supporting member **18***a* for supporting the feeder body **16***a*.

The feeder body **16***a* is provided with a vibration body **161***a* to which a feeder ball **14***a* is attached and a base **162***a* disposed below the vibration body **161***a*. Both of the vibration body **161***a* and base **162***a* have a cylinder-like shape and are connected to each other by a plurality of plate springs **163***a* that are disposed along the circumferential direction with regular intervals therebetween. Each of the plate springs **163***a* has a specific inclination relative to the central line C direction of the vibration body **161***a* and base **162***a*.

The base **162***a* is provided with an electromagnet **164***a* in a concave portion in the central portion thereof, and by causing the movable core (not shown) attached to the vibration body **161***a* to face the pole surface of the electromagnet **164***a*, torsional vibration can be applied to the vibration body **161***a*. The torsion axis, which functions as the center of the torsional vibration, is aligned with the central line C of the feeder ball **14***a*, vibration body **161***a* and base **162***a*. The structure for applying torsional vibration to the vibration body **161***a* is not limited to that of the present embodiment, and a known structure can be selected, for example, a plate spring is driven by supplying a voltage using a piezoelectric element.

The main body supporting member **18***a* is attached to the bottom surface of the cylindrical base **162***a* with a vibration isolator (not shown) formed from rubber or spring therebetween. The main body supporting member **18***a* is formed to have a wedge-like shape as seen from the side view, and supports the feeder body **16***a* on the horizontal floor surface F in such a manner that the central line C of the vibration body **161***a* and the base **162***a* is inclined relative to the vertical direction V. The main body supporting member **18***a* may be structured so as to be fixable to the floor surface F using a bolt or like connecting member. The feeder body **16***a* and the main body supporting member **18***a* do not have to be separately formed, and the main body supporting member **18***a* may be integrally formed in the lower portion of the feeder body **16**. In this case, the main body supporting member **18***a* may be structured so as to be fixed to a supporting plate (not shown) or like horizontal floor via a vibration isolator. If the angle α formed between the vertical direction V and the central line C is unduly small, achieving the effects of the present invention tends to become difficult, and when the angle α is unduly large, conveyance of the objects tends to become difficult. The angle α can be suitably selected considering these facts. According to the experimental results described later, the angle α is preferably in the range of 1° to 10°, more preferably 2° to 7°, and even more preferably 3° to 7°. However, as long as a vibrating feeder **12***a* having a satisfactorily high conveyance ability is usable, the angle α may be greater than 10°.

As shown by the dashed line in FIG. **4**, the conveyance planes of the ascending rail **143***a* and the descending rail **144***a* are downwardly inclined toward the outer radial direction when the vibrating feeder **12***a* is disposed on the horizontal floor surface F. This structure makes it easier to convey the objects on the ascending rail **143***a* and descending rail **144***a* along the guide wall **142***a*, facilitating aligned conveyance. The aligning rail **145***a* disposed downstream from the descending rail **144***a* in the conveyance direction has a narrower conveyance path as shown in FIG. **5** so as to hold a single line of the objects D, and excessive objects D that are not introduced into the guide rail **145***a* fall on the bottom wall **141***a*. As far as the objects can be conveyed in an aligned condition, the aligning rail **145***a* may be formed so as to have a plurality of conveyance lines. The objects that have passed through the aligning rail **145***a* are kept in an aligned condition as shown in FIG. **3** by the guide rail **149***a* and are then supplied to the carrying device **20**. The guide rail **149***a* is not necessarily required and the objects may be supplied directly to the carrying device **20** from the end of the aligning rail **145***a*.

FIG. **6** is a side elevation view illustrating the inclination condition of the ascending rail **143***a*, the descending rail **144***a*, the aligning rail **145***a*, and the guide rail **149***a* of FIG. **3** as developed along the chain double-dashed line B, which is the conveyance direction as seen in a plan view. The inclination condition of FIG. **6** corresponds to the case where the angle α made between the vertical direction V and the central line C shown in FIG. **4** is 5°. In other words, the graph of FIG. **6** illustrates the relationship between the angle relative to the center of the feeder ball **14***a* and the vertical height from the initial point, when the former is defined as a horizontal axis and the latter is defined as a vertical axis.

As shown in FIG. **6**, the ascending rail **143***a* has an upward slope along the guide wall **142***a*. The inclination of the ascending rail forms a smooth sine curve such that it is small at the beginning, gradually becomes large, and then becomes small again at the end. In contrast, the descending rail **144***a* is downwardly inclined along the guide wall **142***a*. The inclination of the descending rail **144***a* forms a sine curve that gradually becomes larger in the conveyance direction toward the downstream direction, and the amplitude of the sine curve of the descending rail **144***a* is smaller than that of the ascending rail **143***a*. This allows the ascending rail **143***a* to reliably convey the objects in the upward direction and the descending rail **144***a* to accelerate the conveyed objects in a short time so that they can be aligned.

It is preferable that the inclination of the ascending rail **143***a* and the descending rail **144***a* form a sine curve as shown in FIG. **6** so as to facilitate smooth conveyance and alignment of the objects, but they may be a different type of smooth curve or a straight line.

The ascending rail **143***a* is formed so as to extend to a location that is 180° ahead of the starting point relative to the center of the bottom wall **141***a*, and the descending rail **144***a* is formed so as to extend to a location that is 90° ahead of the end of the ascending rail **143***a*. In the present embodiment, the ascending rail **143***a* directly connects to the descending rail **144***a*; however, a conveyance path that is parallel to the horizontal floor may be disposed between the ascending rail **143***a* and the descending rail **144***a*.

As shown in FIG. **6**, the end of the descending rail **144***a* (the location 270° from the stating point) has the greatest downward inclination, and the aligning rail **145***a* and the guide rail **149***a* are sequentially connected from this location. The inclinations of the aligning rail **145***a* and the guide rail **149***a* are formed so as to maintain the sine curve of the descending rail **144***a*.

The structure of the vibrating feeder **12**b is the same as that of the vibrating feeder **12**a described above. Accordingly, the objects are aligned and conveyed from the feed portions **146**a and **146**b of the vibrating feeders **12**a and **12**b toward the carrying device **20**.

As shown in FIGS. **1** and **2**, the carrying device **20** is provided with a forward conveying member **21**, return conveying members **22**a and **22**b, and a back/front reversal device **23**. The forward conveying member **21** receives the objects from the vibrating feeders **12**a and **12**b and transports them in two lines (right and left). The return conveying members **22**a and **22**b are disposed on the right and left of the forward conveying member **21** and linearly convey the objects in the direction opposite to the conveying direction of the forward conveying member **21**. The back/front reversal device **23** receives the objects from each line of the forward conveying member **21**, turns the objects over and then transfers them to the return conveying members **22**a and **22**b.

Both the forward conveying member **21** and the return conveying members **22**a and **22**b are formed from conveyor belts, which are driven at the same speed by a servomotor or the like. Each of the conveying belts is formed of a milky-colored semitransparent material with light transmittance and light diffusibility. For example, a polyester belt provided by Nitta Corporation (product name: New Light Grip P-0) is usable. The conveying belt does not have to be milky-colored. It is preferable that the conveying belt be a light color that can exhibit light transmittance and light diffusibility for reliably inspecting the appearance of the object D as described later. Specifically, the conveying belt has a Munsell value of preferably not less than 7, more preferably not less than 7.5, and even more preferably not less than 8. However, even when the Munsell value of the conveying belt is about 5, reliable appearance inspection can be conducted if the lightness of the object itself is low. The conveying belt may be formed of a transparent material, and the same effects as those of the present embodiment can also be achieved in this case. When a conveying belt formed of a transparent material is used, it is preferable that a bright light source be used as a lower lighting device **32**.

In the conveyance plane of each conveying belt, a groove **24** extending in the conveying direction is formed in such a manner that it corresponds to each line of the objects. The groove **24** has a circular cross section (including an elliptic arc) that has a width that is smaller than that of the object, and a depth that can hold only a portion of the object (for example, in the case of tablets, about 0 mm to 1 mm). Press rollers **25** are provided at the location where the conveyed objects are transferred from the vibrating feeder **12**a (**12**b) to the forward conveying member **21**, as shown in FIG. **1**.

As shown in FIGS. **7** and **8**, the back/front reversal device **23** is provided with inclined drums **231**a and **231**b and an inversion drum **232**. The inclined drums **231**a and **231**b are slidably and rotatably supported relative to the inclined surfaces **233**a and **233**b, which are disposed on the right and left sides of the suction box **233**, which is connected to a vacuum pump (not shown). In this structure, as shown in FIG. **7**, when seen along the conveying direction of the forward conveying member **21** and return conveying members **22**a and **22**b, the rotation axes R1 and R2 are arranged so as to be inclined relative to the conveyance planes of the forward conveying member **21** and return conveying members **22**a and **22**b (i.e., when the appearance inspection device **1** is placed on a horizontal floor, they are inclined relative to the horizontal surface).

The shapes of the inclined drums **231**a and **231**b and inversion drum **232** may be disc-like, rather than the usual cylinder-like (drum) shape. In the present embodiment, the inclined drums **231**a and **231**b have a disc-like shape and the inversion drum **232** has a cylinder-like shape.

In the peripheral surfaces of the inclined drum **231**a and **231**b, many suction ports **234**a and **234**b are continuously formed along the circumferential direction. The suction ports **234**a and **234**b are communicably opened to the inside of the suction box **233** via the notches **235**a and **235**b in the inclined surfaces **233**a and **233**b of the suction box **233**. This arrangement allows the inclined drums **231**a and **231**b to hold, by means of suction, each of the objects D conveyed in each line of the forward conveying member **21**, and then to transfer them in the direction shown by the arrow in FIG. **8**.

The inversion drum **232** is supported in such a manner that its rotation axis extends in the horizontal direction so that the inversion drum **232** rotates by sliding relative to the perpendicular plane **236** of the suction box **233**. In both sides of the peripheral surfaces of the inversion drum **232**, many suction ports **237**a and **237**b are continuously formed along the circumferential direction. The suction ports **237**a and **237**b are communicably opened to the inside of the suction box **233** via the notch **238** formed in the perpendicular plane **236**. This arrangement allows the objects D conveyed by the inclined drum **231**a and **231**b to rotate with inclination and be transferred to the suction ports **237**a and **237**b of the inversion drum **232** at a location separated therefrom by the distance h in the direction parallel to that the forward conveying member **21** and the return conveying members **22**a and **22**b are arranged (i.e., perpendicular to the conveying direction along the conveyance plane), and then the conveyed objects D are held by suction on the peripheral surface of the inversion drum **232**.

The transfer distance h of the conveyed objects D in the parallel direction corresponds to the distance between the groove **24** of the forward conveying member **21** and the groove **24** of the return conveying members **22**a and **22**b. The conveyed objects D are guided above the grooves **24** of the return conveying members **22**a and **22**b by the rotation of the inversion drum **232** in the direction shown by the arrow of FIG. **8**, and then transferred to the return conveying members **22**a and **22**b by injecting compressed air from the compressed air nozzle **239**.

As shown in FIGS. **1** and **2**, five image-pickup devices **30**a, **30**b, **30**c, **30**d, and **30**e are disposed in the vicinity of the forward conveying member **21** and the return conveying members **22**a and **22**b in such a manner that images of the conveyed objects D being conveyed can be captured from upper directions. Lighting devices **31** and **32** are disposed immediately above and below the forward conveying member **21** and the return conveying members **22**a and **22**b. The lighting devices **31** and **32** illuminate the conveyed objects D by guiding the light emitted from an incandescent lamp or like light source using optical fiber.

All of the image-pickup devices **30**a to **30**e are line sensor cameras, which scan in the direction intersecting the image-pickup axis and output signals corresponding to the lightness of the conveyed objects D (i.e., output signals substantially proportional to the light amount received by the line sensors). Among the image-pickup devices **30**a to **30**e, two image-pickup devices **30**a and **30**b are arranged so that they face each other on the image-pickup axis I1 as seen in a plan view. Two other image-pickup devices **30**c and **30**d are arranged so that they face each other on the image-pickup axis I2 that perpendicularly intersects the image-pickup axis I1 as seen in a plan view. The image-pickup devices **30**a to **30**d are arranged so that they can substantially simultaneously capture images of the conveyed objects D being conveyed in two lines by the forward conveying member **21**, and, the conveyed objects D being conveyed by return conveying members **22**a and **22**b in one line from upper oblique directions on the image-pickup axis I1 or I2. In other words, each of the image-pickup devices **30**a to **30**d can simultaneously capture an image of four conveyed objects D in each conveying line along the same scanning line.

The remaining image-pickup device **30**e is disposed so that it can capture images of the conveyed objects D from directly above. In other words, the image-pickup device **30**e can capture images of the front surfaces of the conveyed objects D being conveyed by the forward conveying member **21** and the back surfaces of the conveyed objects D being conveyed by the return conveying members **22**a and **22**b along the same scanning line.

The defect detection device **40** is provided with an image formation member **41** and an image processing member **42**. The image formation member **41** generates two-dimensional image data of the conveyed objects D based on the signals output from each of the image-pickup devices **30**a to **30**e. The image processing member **42** extracts the region in which the amount of light received is less than a predetermined level from the image data generated by the image formation member **41** to conduct inspection. The defect detection device **40** determines whether or not the individual object D passes or fails the inspection based on the inspection results of the image processing member **42**. Each of the objects D conveyed by the return conveying members **22**a and **22**b is classified into "accepted" or "rejected" using the screening device **43**. The accepted objects D are transferred onto a defect-free product recovery belt **44** to be picked up. The rejected objects are discharged into a defective product holder **45**.

The operation of the appearance inspection device **1** is explained below. In FIGS. **1** and **2**, when many objects to be tested, such as tablets, are placed in the hopper **10**, the objects are supplied to the vibrating feeders **12**a and **12**b via the chutes **11**a and **11**b, and then conveyed along the ascending rail **143**a, descending rail **144**a, and aligning rails **145**a shown in FIG. **3**.

Each of the ascending rail **143**a, descending rail **144**a, and aligning rails **145**a has an inclination as shown in FIG. **6**. Therefore, the objects are conveyed at a low speed on the ascending rail **143**a, which has an upward slope, and they are conveyed at a higher speed on the descending rail **144**a, which has a downward slope. Accordingly, the piling of the objects D conveyed on the ascending rail **143**a as shown in FIG. **9**(a) separates as shown in FIG. **9**(b) when they are transferred onto the descending rail **144**a and their speed is accelerated. Therefore, while being conveyed on the descending rail **144**a, the conveyed objects D are aligned as shown in FIG. **9**(c). The descending rail **144**a allows the conveyed objects D to align along the guide wall **142**a before being supplied to the aligning rails **145**a, so that the conveyed objects D can be introduced into the aligning rails **145**a smoothly. The aligning rails **145**a are structured so that the conveyed objects pass therethrough in a single line.

The conditions of the objects conveyed by a vibrating feeder are explained below with reference to FIG. **10**. As shown in FIG. **10**(a), in a vibrating feeder whose torsion axis C of the torsional vibration aligns with the vertical direction V, the force F for transporting the object D with the torsional vibration, regardless whether the object is on an ascending rail R1 or on a descending rail R2, is applied in the same direction relative to the horizontal floor. Accordingly, the angle θ**1** made between the conveyance plane of the ascending rail R1 and the application direction of the conveyance force F is small, and the angle θ2 made between the conveyance plane of the descending rail R**2** and the application direction of the conveyance force F is large.

In the vibrating feeder **12**a of the present embodiment, a torsion axis C of the torsional vibration is inclined relative to the vertical direction V as shown in FIG. **10**(b). Therefore, the angle θ**3** formed between the conveyance plane of the ascending rail **143**a and the application direction of the conveyance force F is larger than the angle θ**1** shown in FIG. **10**(a), and the angle θ**4** formed between the conveyance plane of the descending rail **144**a and the application direction of the conveyance force F is smaller than the angle θ**2** shown in FIG. **10**(a). Accordingly, the vibrating feeder **12**a of the present embodiment makes it possible to apply stronger climbing force to the conveyed objects D in the ascending rail **143**a, and, in the descending rail **144**a, the objects D can be conveyed faster.

As a result, in the vibrating feeder having its torsion axis C aligns with the vertical direction V as shown in FIG. **11**(a), the conveyed objects D supplied to the bottom wall R rise on the ascending rail R1 in a piled status (status S**1**→S**2**→S**3**), sufficient acceleration does not take place when they move down the descending rail R2, and they are supplied to the aligning rail R**3** in a status (status S**4**→S**5**) in which they are not sufficiently spread. This increases the excessive conveyed objects D, which are supplied to the bottom wall R without being aligned in the aligning rail R**3** (status S**6**), and makes it difficult to supply conveyed objects D from the guide rail R**4** at a sufficient speed (status S**7**).

In contrast, with the vibrating feeder **12**a of the present embodiment, which has a torsion axis C of torsional vibration inclined relative to the vertical direction V, a large number of conveyed objects D supplied to the bottom wall **141**a reliably rise on the ascending rail **143**a due to a large climbing force in a piled status (status S**1**→S**2**→S**3**) at a slow speed, and the objects come down the descending rail **144**a with sufficiently accelerated speed so that the conveyed objects D can be sufficiently aligned (status S**4**→S**5**). Accordingly, there are almost no excessive conveyed objects D supplied from the aligning rail **145**a to the bottom wall **141**a (status S**6**). This allows the conveyed objects D to be supplied from the guide rail **149**a at high speed. (Status S**7**).

The vibrating feeder **12**a of the present embodiment is structured so that the downward inclination of the descending rail **144**a gradually increases in the downstream conveyance direction of the objects D. This allows the conveyed objects D to smoothly increase in speed and to be easily spread.

The descending rail **144**a is structured so that its downward inclination becomes the greatest at the portion connecting to the aligning rail **145**a, and therefore the conveyed objects D can be supplied to the aligning rail **145**a in the most spread condition, and high-speed conveyance of the objects D can be reliably conducted.

By setting the amplitude of the sine curve of the descending rail **144**a smaller than that of the ascending rail **143**a as in the present embodiment, a step can be easily formed between the aligning rail **145**a and the bottom wall **141**a, and excessive objects D returning from the aligning rail **145**a to the bottom wall **141**a can be easily guided to the ascending rail **143**a again.

The arrangement of the vibrating feeder **12**a of the present invention allows the conveyed objects to be automatically aligned, and therefore a regulation plate for forcibly aligning the objects is unnecessary. Even if a regulation plate is provided, collisions of the conveyed objects and the regulation plate can be prevented and the risk of chipping or cracking of the conveyed objects can be reduced. The greater the difference in speed between the ascending rail and the descending rail, the more remarkable the effects. Therefore, the vibrating feeder of the present invention is particularly effective when high-speed conveyance is performed (for example, 100,000 to 160,000 tablets an hour per line). The inclination angle and connection location of the ascending rail and the descending rail can be suitably selected depending on the conveyance amount and shape of the test objects so that the test objects can be easily aligned.

The aligned objects discharged from the vibrating feeders **12***a* and **12***b* are transferred onto the forward conveying member **21**. As shown in FIG. **12**, by setting the supply speed from the vibrating feeders **12***a* and **12***b* as V**1**, and the conveyance speed of the forward conveying member **21** as V**2**, which is faster than V**1**, the space between the conveyed objects D in each line of the forward conveying member **21** can be increased. A desirable space can be obtained by adjusting the difference between V**1** and V**2**. The press rollers **25** rotate at substantially the same speed as the conveyance speed V**2** of the forward conveying member **21**. This prevents jumping or misalignment of the conveyed objects D when they are transferred from the vibrating feeders **12***a* and **12***b* to the forward conveying member **21**, and reliably positions the conveyed objects D on the groove **24** of the forward conveying member **21**.

As shown in FIG. **13**(*a*), part of the bottom surface of each object D positioned on the groove **24** is placed in the groove **24**. Therefore, as shown in FIG. **13**(*b*), the height L**1** of the forward conveying member **21** as measured from the conveyance plane becomes slightly shorter than the actual height of the object. When the conveyed objects D horizontally rotate while being conveyed on the forward conveying member **21**, the conveyed objects D are stabilized in the position (direction) that makes the height from the conveyance plane of the forward conveying member **21** shorter, as shown in FIGS. **14**(*a*) and **14**(*b*), and are conveyed while maintaining the position in which the height becomes the lowest L**2**.

By forming grooves **24** in the forward conveying member **21**, even if the conveyed objects are irregularly shaped tablets or capsules, they can automatically be adjusted so that their position has maximum stability. This arrangement allows each object to be conveyed in an aligned condition with a fixed position. It is preferable that the groove **24** have a circular (including an elliptic arc) cross section as in the present embodiment. This arrangement allows the height of the conveyed objects from the conveyance plane to easily vary in accordance with their position. However, the cross section of the groove **24** does not have to be an arc and may be rectangular. If the conveyed objects D have a cross section that does not cause a change in the position during the conveyance, such as a square shape, the groove **24** may be omitted.

The conveyed objects D, after having their positions adjusted on the forward conveying member **21**, pass through the image-pickup area where image-pickup devices **30***a* to **30***e* are disposed. Subsequently, they are turned over by the back/front reversal device **23**, and then conveyed in the opposite direction by the return conveying members **22***a* and **22***b*. The operation of the back/front reversal device **23** is the same as that explained above, i.e., by passing through the inclined drum **231***a* and **231***b* and the inversion drum **232**, which can hold the conveyed objects on the peripheral surfaces thereof, the conveyed objects transferred to the return conveying members **22***a* and **22***b* can be reliably turned over. By placing the conveyed objects D in the groove **24** of the return conveying members **22***a* and **22***b*, the positions of the conveyed objects D conveyed by the return conveying members **22***a* and **22***b* can also be automatically adjusted. The conveyance of the objects D in the forward direction by the forward conveying member **21** and in the reverse direction by the return conveying members **22***a* and **22***b* can thus be continuously conducted.

In the image-pickup area of each image-pickup device **30***a* to **30***e*, the conveyed objects D are irradiated from above and below thereof with light emitted from the lighting devices **31** and **32**. Because the conveying belt used in the forward conveying member **21** and return conveying members **22***a* and **22***b* of the present embodiment has a high light-transmitting color, such as a milky-colored semitransparent belt with light transmittance and light diffusion, the conveyed objects D can be uniformly illuminated by radiating light from above and below the conveyed objects D. This arrangement also makes the light-transmitting color that serves as the background of the objects D conspicuous, so the objects D are observed as dark portions.

Each of the four image-pickup devices **30***a* to **30***d* scans in the direction perpendicular to the image-pickup axes **11**, **12** shown in FIG. **2**, so that images of the individual objects D being conveyed on the forward conveying member **21** and the return conveying members **22***a* and **22***b* can be captured. As a result, images of the top surface of an object D being conveyed on the forward conveying member **21** are captured from four upper oblique directions W, X, Y, and Z, as shown in FIG. **15**. Likewise, images of the back surface of an object D being conveyed on the return conveying members **22***a* and **22***b* are captured from four upper oblique directions. Accordingly, a single line of scanning conducted by the image-pickup devices **30***a* to **30***d* makes it possible to generate output signals having a degree of light that corresponds with the receptive light. By repeatedly scanning while conveying the objects D, the output signals corresponding to the scanning are sequentially transmitted to the defect detection device **40**.

In the present embodiment, the forward conveying member **21** and the return conveying members **22***a* and **22***b* are disposed in parallel and arranged so that each object is conveyed in such a manner that its top and back surfaces are exposed. Therefore, by simultaneously capturing images of each object conveyed on the forward conveying member **21** and the return conveying members **22***a* and **22***b* along the same scanning line using a plurality of image-pickup devices **30***a* to **30***d*, the entire appearance of the object can be easily and reliably inspected.

In the defect detection device **40**, based on the output signals from each of the image-pickup devices **30***a* to **30***d*, image formation member **41** generates two-dimensional image data corresponding to the scanning line. For example, when an arbitrary image-pickup device scans an object D conveyed on the forward conveying member **21** along the scanning line **S1** as shown in FIG. **16**(*a*), the image data generated based on the output signals are as shown in FIG. **16**(*b*).

The objects D are generally tablets, capsules, etc. Therefore, depending on the color of the objects D, the difference in the lightness of color between the objects D and the background is very small. This may make it difficult to distinguish the objects D from background. Because the conveying belt used in the present embodiment is formed of a milky-colored semitransparent material with light transmittance and light diffusion, the lightness on the conveyance plane, which becomes the background, is higher than that of the objects D. As a result, as shown in FIG. **16**(*b*), in the image data, the portion corresponding to the object D can be observed as the portion with less lightness (i.e., the amount of light received by the line sensors is smaller) than the background.

As a result, if a chip e**1** and/or a projecting strand of hair e**2** exists on the scanning line S**1** of the object D as shown in FIG. **16**(*a*), these defects can be observed as the regions b**1** and b**2** with less lightness (i.e., the amount of light received by the line sensors is smaller) than that of the object D as shown in FIG. **16**(*b*). Objects D are inspected in the following manner. The first criteria value T**1** is set higher than the lightness (the amount of light received by the line sensor) of the objects D and then the image processing member **42** extracts the image data having a lightness equal to or lower than the first criteria value T**1**, so that the objects D can be distinguished from the background. The defects of the objects D can be detected by, for example, setting the lightness (the amount of light received by the line sensor) of the second criteria value T**2** lower than that of the objects D, and extracting the image data equal to or lower than the second criteria value T**2**.

With such a defect detection method, defects protruding from the object and defects in the edge portions, which are sometimes overlooked by conventional methods because they assimilate with the conveying belt, can be reliably detected. Furthermore, not only the edge portions and the outside of the images of the object, but also defects that exist inside the object can be reliably detected. For example, as shown in FIG. **16**(*a*), if a foreign substance is adhered to the object D on the scanning line S**2**, the foreign substance can be recognized as the region b**3** having a signal value lower than the signal level of the object D as shown in FIG. **16**(*c*).

In the present embodiment, images of the top and back surfaces of each object D are captured from four upper oblique directions as described above to detect the presence of defects. This makes it possible to conduct an inspection without a dead angle. In particular, when the object is annular (doughnut shaped), it is difficult to capture images of the defects on the inside perimeter of the object by known methods. However, the appearance inspection device of the present embodiment can reliably capture images of such inside perimeters. Combining this with the ability to conduct reliable defect detection of the image data allows the appearance of the object to be reliably inspected.

In the present embodiment, images of each object are captured along the same scanning line by each of the image-pickup devices **30***a* to **30***d* while the object is being conveyed on a forward conveying member **21** and the return conveying members **22***a* and **22***b*. This makes it possible to inspect the object by capturing images of the top and back surfaces thereof using the same image-pickup devices **30***a* to **30***d*. Therefore, unlike inspections using different image-pickup devices for the front surface inspection and the back side inspection, calibration of the cameras and confirmation of the inspection accuracy do not have to be conducted so often, making camera validation easier.

In the present embodiment, in addition to the above-described four image-pickup devices **30***a* to **30***d*, an image-pickup device **30***e* is further provided for capturing images of the top and back surfaces of the object in the perpendicular direction. The defect detection device **40** generates image data in the image processing member **42** based on the output signals from the image-pickup device **30***e*, and detects defects mainly in printed portions by comparing this image data with a master image.

The forward conveying member **21** and the return conveying members **22***a* and **22***b* convey the objects at predetermined intervals and a predetermined speed. This arrangement allows the defect detection device **40** to specify the object that corresponds to the image data containing defects by determining which image-pickup device **30***a* to **30***e* captured the signal, based on the image data that was generated in the image formation member **41**, and the timing with which the signal was input. When an object containing a defect is conveyed to the screening device **43**, the object is discharged into the defective product holder **45**.

One embodiment of the present invention is explained above, but the embodiments of the present invention are not limited to this. For example, in the present embodiment, the image-pickup devices **30***a* to **30***d* face each other on two perpendicularly intersecting image-pickup axes as seen in a plan view, so that the number of image-pickup devices can be reduced while also reliably eliminating any dead angle in the captured image. However, insofar as no dead angle is formed, various arrangements are possible, and therefore, for example, the image-pickup axes do not necessarily have to intersect at right angles, and the image-pickup devices **30***a* to **30***d* do not have to be disposed so as to face each other.

To simplify camera validation, the present embodiment has a structure in which the forward conveying member **21** and return conveying members **22***a* and **22***b* are arranged in parallel, and the image-pickup devices **30***a* to **30***d* are disposed so that each of them can capture images of the top and back surfaces of the object along the same scanning line. However, the image-pickup devices may be arranged so as to capture the images of the object conveyed by the forward conveying member **21** and the return conveying members **22***a* and **22***b* individually. In this case, the forward conveying member **21** and the return conveying members **22***a* and **22***b* do not have to be arranged in parallel, and may have an alternate arrangement depending on the space available.

The number of image-pickup devices for capturing images of an object from an upper oblique direction is four in the present embodiment; however, as long as a plurality of image-pickup devices are provided, the same effects as those of the present embodiment can be attained. In order to reliably prevent any dead angle, it is preferable that three or more image-pickup devices be provided. It is also preferable that the plurality of image-pickup devices be disposed along the periphery of the image-pickup area with the same interval between each image-pickup device so that uniform images can be captured.

In the carrying device **20** of the present embodiment, one of the return conveying members **22***a* and **22***b* is disposed on either side of the forward conveying member **21**; however, it is also possible to dispose a forward conveying member on both sides of the return conveying member. Furthermore, the conveyance lines of the forward conveying member **21** and the return conveying members **22***a* and **22***b* in the present embodiment consist of two lines, but may be a single line, or three lines or more.

In the present embodiment, the back/front reversal device **23** is provided with the inclined drums **231***a* and **231***b* and the inversion drum **232**. By positioning the rotation axes of the inclined drums **231***a* and **231***b*, which receive conveyed objects from the forward conveying member **21**, in such a way that they are inclined relative to the conveyance planes of the forward conveying member **21** and the return conveying members **22***a* and **22***b*, the conveyed objects from the forward conveying member **21** to the return conveying members **22***a* and **22***b* can be transferred by moving the objects in a parallel direction relative to which the forward conveying member **21** to the return conveying members **22***a* and **22***b* are arranged. The same effect as that of the present embodiment can also be achieved by using an arrangement wherein the drum (first drum) that receives the objects from the forward conveying member **21** is disposed so that its rotation axis extends along the conveyance planes of the forward conveying member **21** and the return conveying members **22***a* and **22***b* (i.e., along the horizontal surfaces), and the drum (the second drum), which receives the objects conveyed from the first drum and transfers them to the return conveying members **22***a* and **22***b*, is disposed so that its rotation axis is inclined relative to the conveyance planes. Alternatively, both the above-mentioned first drum and second drum may be arranged so that their rotation axes are inclined relative to the conveyance planes.

When one or both of the first drum and the second drum are formed as an inclined drum as described above, the inclined drum may be arranged in such a way that its rotation axis is inclined relative to the conveying direction as seen from a position above the conveyance planes. In this case, even if the rotation axis is parallel to the conveyance planes, by rotating and conveying the conveyed objects held on the peripheral surface, the conveyed objects can be transferred in the direction perpendicular to the forward conveying member **21** and the return conveying members **22***a* and **22***b*. This allows the conveyed objects to be transferred from the forward conveying member **21** to the return conveying members **22***a* and **22***b*.

EXAMPLES

In order to define the preferable range a of the angle formed between the vertical direction V and the central line C as shown in FIG. **4**, the following experiment was conducted. A plurality of wedge-shaped main body supporting members **18***a* having different angles were prepared, the angle formed between the vertical direction V and the central line C was defined as a parameter α, and the speed of the aligned conveyed objects was evaluated.

Tablets having a diameter of 7 mm and a thickness of 3 mm were used as conveyed objects, and they were placed in a feeder ball in such an amount that its bulk volume became 100 ml (in Experiment A) and 500 ml (in Experiment B). Subsequently, starting from the point when each conveyed object became fixed in position and the objects were discharged from the feeder ball, the number of conveyed objects was measured for a period of 10 seconds. A "Parts Feeder" (Model No.: DMS-25) manufactured by Shinko Electric Co., Ltd. was used as the vibrating feeder, and the horizontal amplitude and vertical amplitude of the vibrating feeder were set to 0.9 mm and 0.08 mm respectively. The feeder ball that was used had a diameter of 400 mm, and exhibited a curve from the starting point to the height thereof as shown in FIG. **6**.

As a Comparative Example, a feeder body **16***a* was directly placed on a floor surface F without using the main body supporting member **18***a* (i.e., the angle α of FIG. **4** was 0°), and the number of the conveyed objects was measured in the same manner as described above. Table 1 shows the results. The number of tablets having a bulk volume of 100 ml was 680±6, and that having a bulk volume of 500 ml was 3400±20.

TABLE 1

	Angle										
	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°
Number of Objects Discharged (Experiment A)	320	336	357	378	386	408	413	403	298	172	—
Evaluation (Experiment A)	—	C	B	A	A	A	A	A	D	D	—
Number of Objects Discharged (Experiment A)	320	327	351	356	369	384	401	418	430	451	385
Evaluation (Experiment A)	—	C	B	B	A	A	A	A	A	A	A
Overall Evaluation	—	C	B	A	A	A	A	A	C	C	C

In Table 1, the columns Evaluation (Experiment A) and Evaluation (Experiment B) indicate the increased percentage of discharged objects compared to the discharged objects of the Comparative Example (angle α of 0°). The case where the discharge number decreased was ranked D, the case where the discharge number increased by less than 5% was ranked C, the case where the discharge number increased by 5 to 15% was ranked B, and the case where the discharge number increased by not less than 15% was ranked A. The column Overall Evaluation was ranked C when the ranking combinations of (Experiment A) and (Experiment B) were (C, C), (A, D), or (A, -); B when the ranking combination was (B, B); and A when the ranking combination was (A, B) or (A, A). Regarding Experiment A, the number of discharged objects was not evaluated when the angle α was 10°, but it was confirmed that the objects can be conveyed.

As is clear from the results of Table 1, as the angle α formed between the vertical direction V and the central line C becomes greater, the number of objects discharged increases and the speed of the aligned conveyance also increases. However, if the angle α becomes unduly large, it becomes difficult to sufficiently achieve the conveyance ability of the vibrating feeder, resulting in a decreased number of discharged objects. According to the results, it is preferable that the angle α be in the range of 1° to 10°, more preferably 2° to 7°, and particularly preferably 3° to 7°.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a side elevation view of an appearance inspection device according to one embodiment of the present invention.

FIG. **2** is a plan view of the main components of the appearance inspection device of FIG. **1**.

FIG. **3** is an enlarged plan view of the vibrating feeder of FIG. **1**.

FIG. **4** is a side elevation view of the vibrating feeder of FIG. **1**.

FIG. **5** is an enlarged view of the principal parts of the vibrating feeder of FIG. **1**.

FIG. **6** is a side elevation view of the vibrating feeder of FIG. **3** taken along the chain double-dashed line B.

FIG. **7** shows the rear surface of the back/front reversal device of FIG. **1**.

FIG. **8** is an enlarged side view of the back/front reversal device of FIG. **1**.

FIGS. **9**(*a*) to **9**(*c*) illustrate conditions for conveying the object by the vibrating feeder of FIG. **1**.

FIGS. **10**(*a*) and **10**(*b*) are enlarged views of the principal parts illustrating conditions for conveying the objects using the vibrating feeder of FIG. **1**, wherein FIG. **10**(*a*) shows the conditions of the Comparative Example and FIG. **10**(*b*) shows those of the Example.

FIGS. **11**(*a*) and **11**(*b*) are plan views of the principal parts illustrating conditions for conveying the objects using the vibrating feeder of FIG. **1**, wherein FIG. **11**(*a*) shows the conditions of the Comparative Example and FIG. **11**(*b*) shows those of the Example.

FIG. **12** is an enlarged side view showing the area around the press rollers of FIG. **1**.

FIGS. **13**(*a*) and **13**(*b*) are enlarged views of the principal parts of the forward conveying member illustrating conditions for conveying the objects by the forward conveying member of FIG. **1**, wherein FIG. **13**(*a*) is a plan view and FIG. **13**(*b*) is a side elevation view.

FIGS. **14**(*a*) and **14**(*b*) are enlarged views of the principal parts of the forward conveying member illustrating other conditions for conveying the objects by the forward conveying member of FIG. **1**, wherein FIG. **14**(*a*) is a plan view and FIG. **14**(*b*) is a side elevation view.

FIG. **15** shows the image-pickup direction as seen in a plan view of the image-pickup device of FIG. **1**.

FIGS. **16**(*a*) to **16**(*c*) illustrate the method for detecting defects based on the image data of the image-pickup device of FIG. **1**.

EXPLANATION OF REFERENCE NUMERALS

1 inspection device
10 hopper
12*a*, **12***b* vibrating feeder
14*a* feeder ball
141*a* bottom wall
142*a* guide wall
143*a* ascending rail
144*a* descending rail
145*a* aligning rail
149*a* guide rail
16*a* feeder body
18*a* main body supporting member
20 carrying device
21 forward conveying member
22*a*, **22***b* return conveying member
23 back/front reversal device
231*a*, **231***b* inclined drum
234*a*, **234***b* suction port
232 inversion drum
237*a*, **237***b* suction port
24 groove
25 press rollers
30*a* to **30***e* image-pickup devices
31, **32** lighting devices
40 defect detection device
41 image formation member
42 image processing member
D conveyed objects
V vertical direction
C central line (torsion axis)
F floor surface

The invention claimed is:

1. A vibrating feeder comprising:

a feeder ball having a circular bottom wall and a conveyance path formed along the periphery of the bottom wall;

a feeder body for supporting the feeder ball so as to apply torsional vibration and for conveying objects supplied to the bottom wall along the conveyance path; and

a main body supporting member for supporting the feeder body;

the conveyance path comprising an ascending rail and a descending rail that is disposed downstream from the ascending rail in the conveyance direction;

the main body supporting member supporting the feeder body on a horizontal floor so that a torsion axis, which is the center of the torsional vibration, is inclined relative to the vertical direction; and

the ascending rail and the descending rail respectively conveying the objects upwardly or downwardly relative to the horizontal direction with the feeder body being supported by the horizontal floor via the main body supporting member.

2. The vibrating feeder according to claim **1**, wherein the descending rail is structured so that its inclination gradually becomes larger toward the downstream in the conveyance direction of the objects.

3. The vibrating feeder according to claim **1**, wherein the conveyance path comprises an aligning rail for aligning the objects by narrowing the width of the conveyance path toward the downstream in the conveyance direction in the descending rail; and

the descending rail is structured so that the downward inclination is the greatest at the portion where the descending rail is connected to the aligning rail.

4. The vibrating feeder according to claim **1**, wherein the ascending rail and the descending rail have inclinations of sine curves when developed linearly along the conveyance direction and seen from the side; and

the amplitude of the sine curve of the descending rail is smaller than that of the sine curve of the ascending rail.

5. The vibrating feeder according to claim **1**, wherein the descending tail is downwardly inclined toward the outer radial direction.

6. The vibrating feeder according to claim **1**, wherein the angle between the vertical direction and the torsion axis is 3° to 7°.

7. The vibrating feeder according to claim **1**, wherein the angle between the vertical direction and the torsion axis is 2° to 7°.

8. The vibrating feeder according to claim **1**, wherein the angle between the vertical direction and the torsion axis is 1° to 10°.

9. A carrying device provided with the vibrating feeder of claim **1** for use in conveying objects, comprising:

a conveying means for receiving the objects delivered by the vibrating feeder and conveying the objects in a single direction; and

press rollers for pressing the objects against the conveyance plane of the conveying means disposed in a location where the objects are transferred from the vibrating feeder to the conveying means.

10. An appearance inspection device provided with the vibrating feeder of claim **1** for inspecting the appearance of the objects, comprising:

a forward conveying means for receiving the objects delivered by the vibrating feeder of claim **1** and conveying the objects in a single direction;

a returning means for conveying the objects in the direction opposite to that of the forward conveying means, the returning means being disposed in parallel to the forward conveying means;

a back/front reversal means for turning over the front and back surfaces of the objects delivered by the forward conveying means and supplying the objects to the returning means;

a plurality of image-pickup means for capturing images of each object being conveyed by the forward conveying means and returning means from upper oblique directions; and

a defect detection means for detecting the presence of defects based on image data captured by the image-pickup means.

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